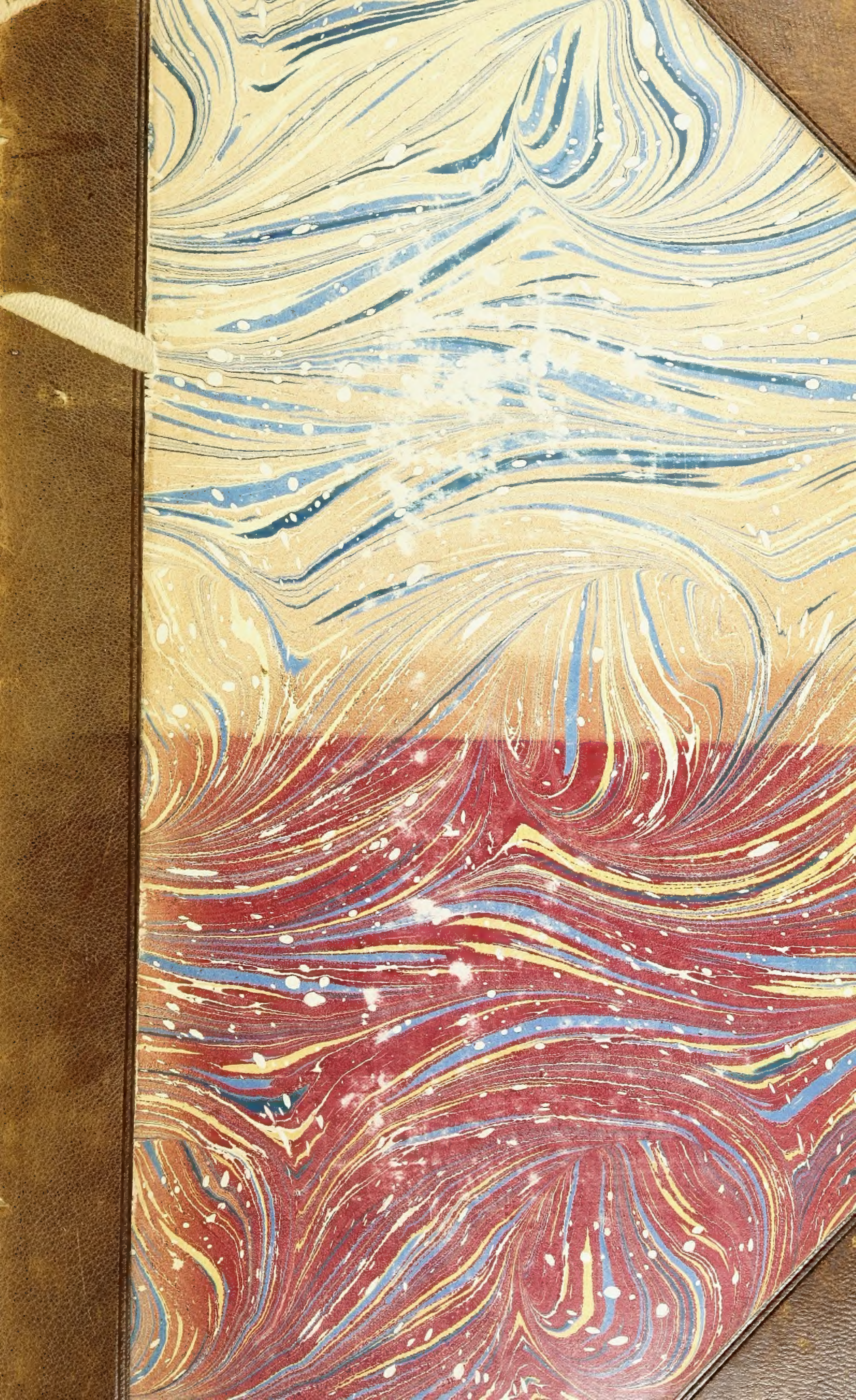

Cornell University Library

The original of this book is in
the Cornell University Library.

There are no known copyright restrictions in
the United States on the use of the text.

http://www.archive.org/details/cu31924012383463

Q 181.G78
v.2

Cornell University Library

Report[s]

3 1924 012 383 463

ROYAL COMMISSION

ON

SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

MINUTES OF EVIDENCE, APPENDICES, AND ANALYSES OF EVIDENCE,

VOL. II.

Presented to both Houses of Parliament by Command of Her Majesty.

LONDON:
PRINTED BY GEORGE EDWARD EYRE AND WILLIAM SPOTTISWOODE,
PRINTERS TO THE QUEEN'S MOST EXCELLENT MAJESTY.
FOR HER MAJESTY'S STATIONERY OFFICE.

1874.

[C.—958.] *Price 6s. 3d.*

CORNELL
UNIVERSITY
LIBRARY

CONTENTS.

B890706

Page
LIST OF WITNESSES - - - - iii
MINUTES OF EVIDENCE - - - - - 1
APPENDICES - - - - - - - *1*
ANALYSES OF EVIDENCE - - - - *73*

LIST OF WITNESSES.

—	Questions.	Pages.
Monday, 12th February 1872.		
William Turner, Esq., M.B.	9,262–9,340	1–7
Alexander Crum Brown, Esq.	9,341–9,396	7–11
Friday, 16th February 1872.		
Peter Guthrie Tait, Esq.	9,397–9,462	12–16
Archibald Geikie, Esq., F.R.S.	9,463–9,503	16–19
Friday, 23rd February 1872.		
William John Macquorn Rankine, Esq., LL.D., F.R.S.	9,504–9,568	19–25
John Young, Esq., M.D.	9,569–9,614	25–30
Friday, 1st March 1872.		
Rev. John Tulloch, D.D.	9,615–9,704	31–35
William Swan, Esq., LL.D.	9,705–9,758	35–38
M. Forster Heddle, Esq., M.D.	9,759–9,790	39–41
Wednesday, 6th March 1872.		
Allen Thomson, Esq., M.D., LL.D., F.R.S.	9,791–9,933	41–50
Friday, 8th March 1872.		
James McClelland, Esq.	9,934–10,019	51–56
James Young, Esq.	10,020–10,058	56–57
Alexander Harvey, Esq.	10,059–10,078	58
Friday, 15th March 1872.		
Albert Günther, Esq., F.R.S.	10,079–10,201	59–65
Wednesday, 17th April 1872.		
C. Wyville Thomson., Esq., LL.D., F.R.S.	10,202–10,310	65–75
Wednesday, 24th April 1872.		
Lieut.-Col. Alexander Strange, F.R.S.	10,311–10,476	75–92
Friday, 26th April 1872.		
George B. Airy, Esq., C.B., F.R.S.	10,477–10,566	93–100
James Prescott Joule, Esq., D.C.L., F.R.S.	10,567–10,673	100–105
Wednesday, 1st May 1872.		
Sir William Thomson, F.R.S.	10,674–10,777	105–114
Friday, 3rd May 1872.		
George Gore, Esq., F.R.S.	10,778–10,919	115–120
William B. Carpenter, Esq., M.D., F.R.S.	10,920–10,962	120–125
Wednesday, 8th May 1872.		
Lieut.-Col. Alexander Strange, F.R.S.	10,963–11,052	125–135
Edward Frankland, Esq., Ph.D., D.C.L., F.R.S.	11,053–11,108	135–138
Friday, 10th May 1872.		
General Sir Edward Sabine, R.A., K.C.B., F.R.S.	11,109–11,274	139–147
Wednesday, 29th May 1872.		
William Froude, Esq., F.R.S.	11,274*a*–11,353	147–152
Friday, 31st May 1872.		
Balfour Stewart, Esq., LL.D., F.R.S.	11,354–11,534	152–171
Wednesday, 5th June 1872.		
Richard Owen, Esq., M.D., F.R.S.	11,535–11,577	171–179
Rear-Admiral George Henry Richards, C.B., F.R.S.	11,578–11,654	179–182

—	Questions.	Pages.
Friday, 7th June 1872.		
Henry W. Chisholm, Esq.	11,655–11,754	182–202
Wednesday, 12th June 1872.		
C. William Siemens, Esq., D.C.L., F.R.S.	11,755–11,873	202–208
Major-General Richard Strachey, R.E., F.R.S.	11,874–11,917	208–216
Friday, 14th June 1872.		
John Anderson, Esq., LL.D., C.E.	11,918–11,969	216–220
William Spottiswoode, Esq., F.R.S.	11,970–12,041	220–224
Wednesday, 19th June 1872.		
Philip Lutley Sclater, Esq., M.A., Ph.D., F.R.S.	12,042–12,137	225–230
Joseph Dalton Hooker, Esq., M.D., C.B., F.R.S.	12,138–12,194	230–234
Friday, 21st June 1872.		
Robert Grant, Esq., LL.D., F.R.S.	12,195–12,291	234–240
J. S. Burdon Sanderson, Esq., M.D., F.R.S.	12,292–12,356	240–244
Wednesday, 26th June 1872.		
Alexander Buchan, Esq., F.R.S.E.	12,357–12,414	245–250
David Milne-Home, Esq., LL.D., F.R.S.E.	12,415–12,547	250–261
Friday, 5th July 1872.		
Major-General Sir Henry C. Rawlinson, K.C.B., LL.D., F.R.S., P.R.G.S.	12,548–12,619	261–270
Wednesday, 10th July 1872.		
Thomas Henry Farrer, Esq.	12,620–12,679	270–277
Alexander W. Williamson, Esq., Ph.D., F.R.S.	12,680–12,704	277–280
Edward J. Reed, Esq., C.B.	12,705–12,729	280–283
Thursday, 11th July 1872.		
The Rev. John Hewitt Jellett, B.D.	12,729*a*–12,820	284–289
The Rev. John R. Leslie, M.A.	12,821–12,888	289–292
Alexander Macalister, Esq., M.B.	12,889–12,960	292–294
Friday, 12th July 1872.		
Captain Douglas Galton, C.B., F.R.S.	12,961–13,033	294–300
Warren De La Rue, Esq., D.C.L., F.R.S.	13,034–13,137	300–306
Edward Townsend, Esq., M.A.	13,138–13,169	306–308
Arthur Hill Curtis, Esq., LL.D.	13,170–13,199	308–310
Wednesday, 17th July 1872.		
Sir Robert Kane, LL.D., F.R.S.	13,200–13,232	310–318
John England, Esq., M.A.	13,233–13,249	318–319
John Purser, Esq., M.A.	13,250–13,315	319–323
Robert O. Cunningham, Esq., M.D.	13,316–13,360	323–325
Thursday, 18th July 1872.		
Robert Dyer Lyons, Esq., M.B.T.C.D.	13,361–13,423	325–331
William Kirby Sullivan, Esq., Ph.D.	13,424–13,480	331–336
Henry Hennessy, Esq., F.R.S.	13,481–13,506	336–338
Wednesday, 13th November 1872.		
The Right Hon. Edward Henry Smith-Stanley, Earl of Derby, F.R.S.	13,507–13,551	338–344
Tuesday, 26th November 1872.		
The Most Hon. Robert Arthur Talbot Gascoigne-Cecil, Marquess of Salisbury, F.R.S.	13,552–13,622	344–350
Wednesday, 27th November 1872.		
The Right Hon. Sir Stafford H. Northcote, Bart., C.B., M.P.	13,622*a*–13,657	350–354
Tuesday, 11th March 1873.		
The Rev. Thomas Fowler, M.A.	13,658–13,752	354–362
Professor Marmaduke Lawson, M.A.	13,753–13,815	362–365

—	Questions.	Pages.
Friday, 14th November 1873.		
Deputation from the Council of the Society of Arts, consisting of— Major-General F. Eardley-Wilmot, R.A., F.R.S., Chairman Mr. Edwin Chadwick, C.B. Lieut.-Col. A. Strange, F.R.S. Mr. Seymour Teulon Col. A. Angus Croll Mr. Hyde Clarke The Rev. Septimus Hansard, M.A. Admiral Ommanney, C.B., F.R.S. Mr. James Heywood, F.R.S. Mr. P. Le Neve Foster, Secretary	—	365-371
Friday, 21st November 1873.		
Trenham Reeks, Esq.	13,816-13,831	371-373
Major John F. D. Donnelly, R.E.	13,832-13,860	373-376

MINUTES OF EVIDENCE

TAKEN BEFORE THE

ROYAL COMMISSION

ON

SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

No. 6, Old Palace Yard, Westminster, Monday, 12th February 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.

WILLIAM TURNER, Esq., M.B., examined.

W. Turner, Esq., M.B.
12 Feb. 1872.

9262. (*Chairman.*) I believe that you are Professor of Anatomy in the University of Edinburgh?—I am.

9263. And previous to your actual appointment as Professor, you had some share, had you not, in the instruction in that department of the University?—Yes, I taught for 13 years as Demonstrator of Anatomy.

9264. Will you describe to the Commission the method of teaching pursued in connexion with the scientific departments of medicine in that University?—I may divide for this purpose the scientific departments of medicine into three groups—one group consisting of the general sciences, in which all medical students are required to obtain instruction; a second group, consisting of sciences which more especially appertain to medicine; and a third group consisting of the special medical subjects themselves. The first group of general sciences includes chemistry, botany, and natural history, by which we especially mean zoology. With reference to the subjects of chemistry and natural history, the professors of those subjects will appear before the Commission and will state their views more fully than I can do, so that you will, perhaps, allow me to pass them over and take up the subject of botany. This subject is taught by a professor giving a three months' course of lectures, five lectures per week, in the lecture room in the Botanical Gardens. The lectures are illustrated by fresh specimens from the garden, by dried specimens from the Herbarium and Museum, and by models and drawings. In addition the professor gives practical demonstrations both in the garden and hothouses, and microscopic demonstrations on the vegetable tissues, and he has each Saturday during the summer a botanical excursion, with the object of making the students acquainted with the botany of the district. Examinations of the class are held at intervals for the purpose of testing the acquirements of the students. To proceed now to the second group. With regard to anatomy, which is my own subject, I give during the winter a course of 100 lectures on the structure of the human body, those lectures being descriptive both of its microscopic structure, and of such parts as can be seen with the naked eye. The lectures are amply illustrated by dissections and preparations of various kinds, and also by diagrams, and I also hold written examinations of the class. In addition I give a course of what is termed anatomical demonstrations, the object being to instruct the students especially in regional anatomy, that is the anatomy of the regions which are more especially important in connexion with medical and surgical practice. In addition I give instruction in practical anatomy in my dissecting room. During the summer I have demonstrations on human and on some branch of comparative anatomy, and the practical work of the class is also conducted during the summer. In fact practical anatomy goes on in the Edinburgh University for 10 months in the year, which is a larger amount of time devoted to the purpose than is usual in the Schools of Medicine in this country. With reference to physiology, there is also a five months' course of lectures, five days in the week, by Professor Bennett, illustrated by diagrams and by experiments of various kinds bearing on the application of physical investigation to vital phenomena. Professor Bennett also holds practical classes in physiology, in which the students are trained in the use of the microscope, and its employment in physiological inquiry. They have also a training in the applications of chemistry and in the use of various instruments which can be applied to physiological investigation—what is termed experimental physiology. With reference to pathology, the Professor of Pathology gives 100 lectures during the winter, five per week; he illustrates his lectures by morbid specimens, and by diagrams, and holds written examinations. He also has a practical class of pathology during the summer, in which students work at diseased structure with the microscope, so as to familiarise themselves with the diseased appearances of the human body. The Professor of *Materia Medica*, Sir Robert Christison, gives a similar course of lectures to those which I have already enumerated, namely, five lectures per week for five months in the year, which include instruction in pharmacy, in therapeutics, in the physiological action of remedies, and in diet and regimen. He also holds class examinations, and he has an excellent museum to which the students have free access for the purpose of learning the characters of various drugs, and making themselves practically acquainted with the subject. He also has

W. Turner, Esq., M.B.

12 Feb. 1872.

a laboratory, but on account of its small size it cannot be used for class teaching. Perhaps I may now say a few words on the more strictly medical subjects. The lectures on the Practice of Medicine consist of a five months' course of five lectures per week, illustrated also by diagrams and preparations. During the summer the professor gives a special course of Medical Psychology with practical instruction in an asylum. The lectures on Surgery are of the same extent, but in addition to illustration by diagrams and preparations the Professor shows the operations on the dead body. He also gives practical instruction in bandaging, and during the summer the students perform under his superintendence operations on the dead subject. The Professor of Midwifery gives also a course of lectures for five months in the year, five days a week, illustrated by specimens in the museum, models and drawings. The Professor of Medical Jurisprudence lectures in summer, and gives about 60 lectures, with experiments in connexion with those departments of the subject which can be illustrated in that manner. The Professors of Clinical Medicine and of Clinical Surgery lecture in the infirmary on patients suffering from disease in that institution. Such is a brief statement of what we do in connexion with our medical teaching.

9265. As regards the means at your disposal for medical teaching, you probably, in the answer which you have just given, have described pretty completely the teaching staff of the University?—Yes, the professorial teaching staff as regards those particular subjects. But our staff of teachers not only consists of Professors, but of Assistants. We have two sets of assistants in the University; one set of assistants appointed by the Professors, the appointment being confirmed by our University Court, which is our highest University authority. Those assistants are allowed us by an ordinance of the Scottish University Commissioners, a Commission which sat in 1860, and introduced most important reforms into our University system, and they associated assistants with certain Chairs. But we have a second group of assistants appointed by the Professors, whose appointments are confirmed by the Senatus, and who are not appointed under the ordinance of the Commissioners, as they have been instituted at a subsequent period. All the Chairs that I have referred to, except those of Clinical Medicine and Surgery, have assistants attached to them, who receive small salaries paid out of the general fund of the University.

9266. Do the functions of the two classes of assistants differ from each other?—No, they do not, but it is simply a difference in the nature of their appointment.

9267. Have any of the Chairs more than one assistant?—I have one assistant allowed me by ordinance of the Commissioners, who receives a salary of 150*l.* from the general University fund, but I have to employ three additional assistants who are paid by me out of my own funds.

9268. May we understand that the first class are paid from the University funds generally?—Both classes of assistants referred to in Answer 9265, whether their appointments are confirmed by the University Court or Senatus, are paid from the University funds: but as regards my other three assistants referred to in Answer 9267, their appointments are not confirmed either by the University Court or Senatus. My reason for employing them is simply due to the circumstance that I have so large a class that the assistant provided by the University is not sufficient for my purpose, and I must, therefore, find other assistants, and that I do on my own responsibility, and pay them myself.

9269. Will you tell us what funds your University has at its command?—The University publishes each year in the calendar a statement showing its income and expenditure: and perhaps the Commission will allow me to give a brief abstract of the finances for 1869–70, as printed in the calendar for 1871–72. The capital of the University, and this is its sole capital, is 144,951*l.* Of this capital 103,556*l.* is specially destined for certain purposes, such purposes, for example, as salaries for certain Chairs, and for scholarships and fellowships, and what we call in Scotland bursaries, which are small exhibitions. The only capital at the disposal of the University which we can apply to other purposes than for those above mentioned is the sum of 41,395*l.*; the interest of which is the only money that we have at our disposal as actual fixed income. But the University receives, in the form of matriculation and graduation fees, an income fluctuating in its amount, which is applied each year to various University purposes. For example, we receive from each student each year a payment of 1*l.*, which is called a matriculation fee, and the sum of money received during 1869–70 from this source was 1,642*l.*, and we received in the shape of graduation fees, 2,022*l.*

9270. (*Dr. Sharpey.*) Does that include the stamp?—No, with the stamp deducted, because we simply collect the stamp duty and hand that over to the Government. This is net. Then we receive compensation for what is called Stationers' Hall privilege, 575*l.*; that goes exclusively to the library. Then we receive a grant of 500*l.* from the Government for the maintenance of the buildings. We receive 49*l.* in the shape of fees for admission to the library of persons not students; 83*l.* by the sale of our calendar, and 50*l.* which I see is put in the calendar, under the head "miscellaneous." Adding these items of annual receipts to the interest of our disposable capital which I have already referred to, gives us a disposable income for general University purposes of 7,375*l.*, which is the only money that we have for disposal, and which forms our general University fund. This income is expended as follows: the general administration of the University, viz., the salary of the secretary, the salary of the clerk, the salary of our factor, that is our man of business, the salary of the Dean of the Medical Faculty, of the Dean of the Faculty of Arts, and the editing of the calendar. Those items amount to 981*l.* a year Then the library absorbs 1,584*l.* annually. Then there is 217*l.* for the support of the anatomical and botanical museums, which is all that we have for museum purposes; the repair, cleaning, heating, and lighting of our buildings, the poor rate and water rate, and insurances, absorb 1827*l.*; for the general service of the University, in the shape of door-keepers, warders, and so on, we spend 595*l.*; 1,465*l.* for class assistants and class expenses; 366*l.* for printing and advertisements; 207*l.* for prizes; 18*l.* for graduation expenses, and 41*l.* for sundries, making altogether 7,301*l.* The balance of unexpended income for the year was only 74*l.* Of this 7,375*l.*, 1,015*l.* is applied to the scientific departments of medicine, which also receive in addition 125*l.* 15*s.* 2*d.* as interest of a part of that capital which I have already stated was specially destined. That is all that goes to medicine from that destined capital.

9271. To medicine in any shape?—Yes, in any shape. For example, the Hope prize fund, which is associated with the chemical department, receives 50*l.* a year of that 125*l.*, the Chair of Natural History receives 35*l.* 15*s.* 2*d.* under what is called the Thomsonian Bequest, and the Chair of Botany receives 40*l.* under what is called the Leith Harbour Annuity, making altogether 125*l.* 15*s.* 2*d.* I ought also to state that certain of the Professors in the Faculty of Medicine receive in the shape of parliamentary grants 1,370*l.*

9272. Is that an additional fund to what you before mentioned?—Yes, and perhaps I might explain to the Commissioners why some of those professors obtain from Parliament such a sum of money. Prior to the Scottish University Commission in the year 1860, the graduation fees in medicine were not, as is the case now, paid into the general University fund, but were divided amongst the Medical Professors who acted as examiners, after certain deductions were made for University purposes. Those fees, therefore, constituted a part of their emoluments; but it was considered to be a bad principle to pay the examiners out of the

W. Turner, Esq., M.B.

12 Feb. 1872.

examination fees, and so the Scottish University Commissioners decided that the examination fees of the candidates for graduation should be paid into the general fund of the University, and by way of compensation Parliament granted to various of those Professors a small salary, which as a general rule is 100*l.* a year; but I may mention that no salary was allotted to the Chair of Anatomy by the Commissioners. I am the only Professor in the University who is left without a salary, and I believe I am the only professor in a Scottish University who has no salary. All my emoluments as Professor are simply what I receive from the students' fees, so that I am in a special position. My colleagues in the Medical Faculty have at least 100*l.* a year in the way of salary derived from the parliamentary grant.

9273. Was that 1,370*l.* a year in addition to the income that the University had previously had?—The Professors were deprived of their graduation fees.

9274. But the graduation fees added so much, did they not, to the general fund of the University?—Precisely; and of course that fund is applied for University purposes, so that the University is by so much the gainer. It is not paid into the Exchequer, it goes into our own general University fund.

9275. (*Professor Stokes.*) Do I rightly understand you that that 100*l.* you mentioned constitutes the sole stipend of the Professors, or only that portion which was given them in lieu of the fees which were taken away?—Perhaps you will allow me to state that the Professors of Chemistry, Physiology, *Materia Medica*, Practice of Medicine, Surgery, Midwifery, and Pathology had no salaries until the Commission gave them the salary which I have referred to in lieu of the graduation fees. The Professor of Chemistry has now 200*l.* a year, the Professor of Physiology has 150*l.* by this parliamentary grant; but the Professors of *Materia Medica*, of Practice of Medicine, of Surgery, of Midwifery, and of Pathology have only 100*l.* a year each; the three Regius Chairs, viz., Clinical Surgery, Medical Jurisprudence, and Natural History, each has a parliamentary grant. The Professors of Clinical Surgery and Medical Jurisprudence have 100*l.* a year. The Professor of Natural History has a somewhat larger sum. I see it put down in the calendar at 160*l.* Prior to the passing of the ordinance of the Scottish University Commissioners the Regius professors then in office had their share of the graduation fees as well as the parliamentary salary, and the Commissioners reserved to the then holders of those Regius Chairs the privilege of still taking their share of the graduation fees so long as they lived; but now those gentlemen have all either died or resigned, and consequently the present holders of the Chairs only get the parliamentary grant, they do not get the graduation fees; but the former professors had a life interest as it were in the graduation fees. Mr. Syme, the Professor of Clinical Surgery during his life for the time that he held the Chair had 100*l.* a year, and his share of the graduation fees; but as soon as he resigned his successor lost the right to share the graduation fees, and had only the salary attached to his Regius Professorship, which is 100*l.*

9276. (*Chairman.*) Can you give the Commission some general notion of how the income of the fixed capital sum is applied; is it applied to other special teaching purposes?—Of this 103,556*l.* the interest of 24,056*l.* is applied by special bequests to the endowments of five Chairs, viz., the Chair of Agriculture, the Chair of Natural History, the Chair of Sanscrit, the Chair of Music, and the Chair of Engineering. The interest of 8,500*l.* is applied to the expenses of the Chair of Music, and the payment of an assistant, under a special bequest by General Reid. The interest of 1,000*l.* goes to the expenses of the engineering Chair. The interest of 8,000*l.* goes to the payment of what is called the Reid Commemoration Concert; General Reid who founded the Chair of Music ordered that a concert should be given annually on his birthday, and the interest of 8,000*l.* is set apart for that purpose. The interest of the remaining 54,720*l.* goes to the bursaries, scholarships, and fellowships; but I should state that those bursaries, scholarships, and fellowships are, with four exceptions, associated with the faculties of arts and theology; with medicine there is only one; with natural science, three. I think that our law faculty has no exhibitions.

9277. Then the parliamentary grant of 1,370*l.* a year goes entirely to professors connected with the department of medicine?—Entirely so, to the professors of the subjects that I have already mentioned at the commencement of my statement.

9278. Will you next proceed to tell the Commission what space you possess for lecture rooms, for museums, and for practical work?—I have brought with me a ground plan of the University buildings (*producing the same*). Our University building is in the form of a quadrangle surrounding a central court; it is a lofty building of three or four stories, because the ground is somewhat irregular, so that we get an additional floor in certain parts of it. It was erected in the latter part of the last century and the early part of the present century. I may show to the Commission what the character of the original college buildings of Edinburgh was. Those were the old buildings (*producing another plan*) of the University of Edinburgh in the last century, like a row of very ordinary cottages; but at the end of the last century it was recognised that they were very inadequate for the purpose, and a public subscription was started in Scotland for the purpose of raising funds, and from an official document which I have here I find that about 30,000*l.* was subscribed, and the college was commenced to be built with that money. I am given to understand that the east side of the present college, the north side, and the north-west corner, were built with that money, but the subscription being exhausted the erection of the building ceased until the Government was prevailed upon to undertake its completion. The building was originally designed by one of the brothers Adam; but when the Government undertook its completion Mr. Adam was dead, and the work was entrusted to Mr. Playfair, the eminent architect, and a man who did so much for the general architecture of Edinburgh, and the Government voted upwards of 129,000*l.* to complete our college buildings, as I see stated in a document which was sent in to the Treasury some years ago, so that the west end, the south end, and the south-east end of the college cost upwards of 129,000*l.* Professor Stokes will I think bear me out that our library hall is one of the most magnificent halls in the country.

9279. Does that comprise the whole of the buildings possessed by the University for all purposes?—The whole of the buildings possessed by the University, with one exception, that is to say, the music-class room, which was built out of a fund provided by General Reid, and which is in another part of the town.

9280. Do you know at all the length of those University buildings from west to east?—Speaking from memory, I think that the surface area covered by that building is about 95,000 superficial feet.

9281. Does that include both court and buildings?—Yes, both court and buildings; it is the entire area. I should like to make a statement which perhaps may be interesting in connexion with the antiquity of some of our Chairs of Science, to show how long we have really had scientific Chairs in the University, and when some of them were founded. The Chair of Botany was founded in 1676, the Chair of Institutes of Medicine, that is to say, the Chair in which physiology is taught, was founded in 1685, the Chair of Practice of Physic in the same year, the Chair of Anatomy in 1705, the Chair of Natural Philosophy in 1708, the Chair of Chemistry in 1713, the Chair of Natural History in 1767. Since the beginning of the present century 11 new Chairs have been founded in the University, four of which Chairs are in the department of medicine, namely, the Chairs of Clinical Surgery, of Medical Jurisprudence, of Surgery, and of Pathology. The remaining seven are

W. Turner, Esq., M.B.

12 Feb. 1872.

not in the department of medicine. Those are the Chairs of Engineering, Geology, Conveyancing, the Theory of Music, Biblical Criticism, Sanscrit, and Political Economy. The point upon which I wish especially now to address the Commission is with reference to what I think I may call our great want, and one in which we really do require aid in the most material manner, and that is for new buildings.

9282. Can you give the Commission some idea of how those buildings are occupied, and the purposes to which they are applied?—For lecture rooms, museums, laboratories, dissecting rooms, and all the various apartments required for giving instruction in medicine, law, theology, and arts, with a large and very valuable library of some 150,000 volumes, and the library takes up nearly the whole of the south side of the college building, and is greatly in want of increased space.

9283. (*Dr. Sharpey.*) Does any professor reside in the college now?—The only persons who reside in the college buildings are the librarian, who resides at the east side, and the janitor, who resides near the gate; there are no professors' residences in the college.

9284. (*Chairman.*) Will you have the goodness to proceed with your statement as to the purposes to which the buildings are applied?—I should wish to mention that we have 18 lecture rooms, and 40 distinct courses of instruction are given in those 18 rooms. Some of the lecture rooms have as many as three distinct courses of instruction each day given in them, and this in many subjects is a matter of excessive inconvenience. The Professor of Pathology, for example, whose subject is one not very agreeable to non-professional people, has to lecture in a room which is used only one hour before he enters it by the Professor of Moral Philosophy, and one hour after he leaves it by the Professor of Geology. But I state this merely to show how much we are hampered for want of class rooms. Another subject which I should like to bring before the Commission is the enormous development which has taken place of late years in practical teaching in connexion with all the departments of scientific medicine, and perhaps I may be allowed to illustrate it from my own subject, anatomy. When the part of the college now set apart for anatomical teaching, namely, the north-west corner, was constructed, the teaching in practical anatomy was confined to a very few students, and could be carried on in a moderate sized apartment; but at this present time all students of medicine are compelled to go through a very stringent course of instruction in practical anatomy; and we require for that purpose spacious, well-ventilated rooms. The Professor of Chemistry will state the same with regard to his subject, and the Professor of Pathology, the Professor of Institutes of Medicine, the Professor of Natural History, the Professor of Surgery, the Professor of Medical Jurisprudence, all require class rooms for practical instruction, and those take up a large comparative amount of space, because you cannot pack the students as you do in a lecture room; they must have space to move about in. The Professor of *Materia Medica* also wished me to state that it would be necessary, in order to carry out the wishes of the Medical Council as regards teaching his subject, that he should have a laboratory, in order that he should teach practical pharmacy; so that we need a great amount of space for this purpose. We have had a committee sitting and receiving reports from the individual professors with regard to our requirements in this particular; and our Committee has drawn up a draft report, some copies of which I have brought with me, and if your grace would wish me, I could leave them with the Commission, and I think they will give in a brief form a statement as to what our needs are as regards space (*delivering in the same*). I may refer to the table on page 4, which gives a brief statement as to what we require. We propose to transplant the Medical School from the present University buildings to a new site, so as to leave the present buildings for the other departments of the University. We are in treaty for the acquisition of a piece of ground excellently situated for our purpose, and we hope to acquire this ground without much delay. We contemplate that we shall require in our new buildings for the Medical School about 60,000 superficial feet; and on that page 4 there is a statement as to how much will be required by each department—Anatomy, 20,000 square feet; Chemistry, 12,000; *Materia Medica*, 5,616; Institutes of Medicine (that is, Physiology) 5,500; Pathology, 4,000; Medical Jurisprudence, Surgery, Practice of Medicine, and Midwifery, 3,000 each. I should mention, in connexion with the very large amount of space which anatomy requires, that this includes not only what is needed for class teaching purposes, but also for the anatomical museum belonging to the University. The University possesses an excellent anatomical museum which was founded by the family of the Monros. It has been largely added to of late years, and at this present time the museum is so full of specimens that it cannot be employed so efficiently as we wish it to be used for teaching purposes, and we positively cannot show, for want of space, numbers of extremely valuable specimens and preparations that we possess, many of which are stowed away in boxes and drawers in a room very imperfectly lighted. Referring again to the plan on the table simply to show where the anatomical museum is situated, the Commission will observe that it is at the north-west corner of the college. On the west side of the college is a street only 16 feet in width, and when the present college was built the ground to the west of this street was a large open space, and then the west side of the college was excellently lighted; but the Government recently acquired this open space, and they have erected upon it the buildings of the Museum of Science and Art. That has been done within the last six or eight years, and the lofty building of the Museum of Science and Art has cut off the light from the west end of the college, and has rendered almost useless the rooms situated on the west side, some of which are the apartments of the Anatomical Museum. Another reason why we are so desirous of having an extension of our buildings is on account of the great increase in the number of our students.

9285. Are the Commission to understand that this 60,000 feet includes everything that you require for all purposes in the Medical Department?—For all purposes in the Medical Department, and we are of opinion that when the medical professors migrate to another building, there will be sufficient space left in the present building for the needs of the professor who will be left in the occupation of it.

9286. You consider that this would supply all the requirements of the University as far as additional space is concerned?—Yes, at this present time it would.

9287. Will you proceed to state to the Commission the number of students receiving instruction in the scientific departments of medicine?—I should like to put in a statement of the number of matriculated students in the University of Edinburgh during the past five years. The whole number of matriculated students in 1867–68 was 1,513; in 1868–69, 1,564; in 1869–70, 1,698; in 1870–71, 1,768; and up to the present date for 1871–72 we have 1,731; but to those will have to be added the summer matriculation, which will probably be about 100 medical students, so that we may estimate the total number for 1871–72 at 1,831 matriculated students. Of those the following belong to the Medical Department. In 1867–68, there were 449; in 1868–69, 516; in 1869–70, 586; in 1870–71, 678; and up to the present time, in 1871–72, 622; and if we allow for our summer matriculation say 100 medical students, that would give us 722 for 1871–72. So that our number represents that of the largest medical school in the country. There is no other school which educates so many in medicine. With reference to my own department, perhaps I might be allowed to state the number attending my own instruction in anatomy. Taking the same five years, there were 200 attending my lectures in 1867–68; in 1868–69, 211; in 1869–70, 240; in 1870–71, 284; and in the present winter, 307. Then attending my practical

W. Turner, Esq., M.B.

12 Feb. 1872.

instruction, that is to say, using my dissecting room, in 1867–68, there were 234; in 1868–69, 217; in 1869–70, 264; in 1870–71, 317; and in the present winter, 333. The amount of accommodation required for the practical instruction of 333 students is of course very large, and the crowded and imperfectly ventilated condition of my practical rooms, which are situated in the upper floor of the building, and therefore inconvenient of access, have this winter been a matter of very considerable anxiety. We get our ventilation and light from the roof.

9288. You have not the whole 300 at work at one time I presume?—Not all at one time, but still I may have perhaps 200 in the rooms at one time.

9289. Over how many years does the course of instruction usually extend?—Four years in medicine.

9290. Then might we multiply this number of matriculations by four to get the number of students actually undergoing instruction at the same time?—No; with us the matriculation is annual. In the Scottish Universities the term "matriculation" has an entirely different meaning from that which it has in the English Universities. In the Scottish Universities no entrance examination is required previous to matriculation, which consists in enrolling the name and signing a declaration in the University album to the effect that the student will be diligent, obedient to his teachers, and loyal to the University. On the enrolment of his name upon the general list of students of the University he pays 1*l.* to the general fund of the University, and that payment of 1*l.* gives to the student the free use of the library for that year. The enrolment of the name, the signing the declaration, and the payment of 1*l.* have to be repeated at the commencement of each year of study.

9291. Will you be so good as to describe the system of examination for the degree in medicine?—The examination for our degree in medicine is divided into three stages: Firstly, an examination in botany, chemistry, and natural history. Secondly, an examination in anatomy, physiology, pathology, and *Materia Medica.* Thirdly, an examination in the practice of medicine, surgery, midwifery, medical jurisprudence, and in clinical medicine and surgery. As to chemistry, natural history, and botany, a student can go up for examination in those subjects either at the end of his second summer, or at the end of his second winter. He can select which time suits him best. If he passes he then goes on for the examination in anatomy, physiology, pathology, and *Materia Medica;* but he cannot proceed for examination in those subjects until the end of his third winter, and then the examination in the remaining subjects takes place in the summer of his fourth year of study. The examinations are in all cases partly written, partly oral, and partly practical. If he succeeds in passing in these various subjects, that is to say, after four years of study, he gets the degree of Bachelor of Medicine, and if he chooses the degree of Master of Surgery; but he can take the degree of Bachelor of Medicine without taking that of Master of Surgery if he is so disposed. There is a small additional fee for the Master of Surgery. The degree of Doctor of Medicine cannot be conferred until the candidate is 24 years of age, and at least two years subsequent to his having received his degree of Bachelor of Medicine. A thesis on some branch of knowledge comprised in the professional examinations for the degree of Bachelor of Medicine must be submitted to and approved by the medical faculty before the doctors' degree is conferred.

9292. Do you not require any preliminary examination of a literary character, or for testing the student's knowledge of mathematics?—We have an excellent preliminary examination which all are obliged to pass. No student can be placed on the register of medical students until he has passed this preliminary examination, and perhaps I might state what the subjects of examination are: they are English, Latin, arithmetic, the elements of mathematics, that is to say, both Euclid and algebra, and mechanics; those are essential, and they must be passed. Then a student may select two out of the following subjects, but he must take two before he can take his Bachelor's degree, Greek, French, German, higher mathematics, natural philosophy, logic, and moral philosophy. If he goes on for the degree of Doctor of Medicine, he must pass in Greek, which is essential, and he must take either logic or moral philosophy.

9293. (*Sir J. P. Kay-Shuttleworth.*) Would the possession of a degree from any other University stand in the place of that preliminary examination?—The degree of Bachelor of Arts from any of the Universities in the United Kingdom, and the London University matriculation examination, would stand in the place of that examination.

9294. (*Chairman.*) Are the examinations in the first year of which you have spoken, namely, the examinations in chemistry, natural history, and botany, confined to medical students, or may other students also go in for those examinations?—Other students may go in for those examinations, because we give a degree in science as well as a degree in medicine.

9295. Will you now go on to describe to the Commission the aid which in your opinion is required in order properly to develope the resources of the University?—The primary matter on which I wish to speak in connexion with this part of my evidence is the great need that we have for an extension of the buildings. From the statement which I have already made to the Commission with reference to our funds, I think it will be seen that our capital is extremely small, and the interest on this capital is absolutely needed for providing for our general administration, our library, museums, the preservation of buildings, and so on, so that the University has of itself no capital to apply for the purpose of erecting new buildings. The University has to ask therefore for money, both for buying the ground and for building the necessary structures. We propose to go to the public and endeavour to raise what we can in the way of subscription. But I may state that the people of Edinburgh and of the surrounding district have, during the past four or five years, raised a sum of upwards of 70,000*l.* for building a new infirmary, so that the public pocket has been, we think, very materially drained for that purpose; and although we may raise, and I hope we shall raise, a considerable sum of money, yet we do not anticipate that we shall be able to collect all that will be needed, and we are desirous of obtaining aid in this respect from the Government. The Government aided the University in the beginning of the present century, when it liberally provided 129,000*l.* for the construction of or completing the construction of our present buildings. The Government also has aided in a most munificent manner the University of Glasgow, and it has provided funds for the Universities of Aberdeen and St. Andrew's, and we are desirous of obtaining assistance from it for our own purposes.

9296. Has an estimate been formed of the sum that will be required for the new buildings, including the purchase of the site?—We hope to obtain the necessary ground for some 18,000*l.* or 20,000*l.*, but we have made no estimate as to what the buildings may cost.

9297. Are you able to give any rough estimate?—I have no experience to enable me to do so.

9298. Although the University have taken steps for acquiring the land, they have not proceeded to make any estimate of the total sum that may be required?—No, we have had no report from the architect on that subject.

9299. (*Sir J. P. Kay-Shuttleworth.*) Have you any apprehension that it will exceed 50,000*l.*?—I think that the buildings themselves may be done for 50,000*l.*, but this is merely a guess at the probable cost.

9300. (*Chairman.*) Would funds also be required for apparatus?—We would say that a grant for extension of buildings and for the necessary fittings is what we are in the first place wishing to ask for.

9301. Are there any other directions in which you

W. Turner,
Esq., M.B.

12 Feb. 1872.

are of opinion that assistance is required for the advancement of scientific medicine?—I conceive that very important assistance might be given to us if we had some increased endowments for the proper payment of assistants, and also for procuring appliances for teaching. In the detailed statement as to scientific instruction, and the means available for the advancement of science in the University of Edinburgh, with suggestions for the improvement of the same, which the University has handed in to the Commission, if the Commissioners will look at the sums of money paid to our assistants by the University, they will see that those sums are in many cases miserably inadequate. The Professor of Physiology, for example, has only 100*l.* allowed for his assistant. Now the assistant's time is entirely taken up, and he is working nine or ten months in the year the greater part of the day. I myself have only an allowance of 200*l.* for the payment of my principal assistant or demonstrator, whose time is entirely devoted to the work of the class, and for the other expenses of my class, which is very inadequate to the purpose, and I have already stated that I have to provide three additional assistants out of my own private means.

9302. (*Dr. Sharpey.*) There is a separate fee, is there not, for lectures on anatomy and for practical anatomy?—Yes; the fee for the lectures is four guineas for the first year, and the fee for practical anatomy is three guineas.

9303. (*Sir J. P. Kay-Shuttleworth.*) Does that include also the provision of subjects?—The students pay a small additional sum for each part; 7*s.* is the sum that they pay. I may also state that the Professor of Natural History has only 30*l.* a year allowed for his assistant, the Professor of Botany has 25*l.* allowed for his assistant, and the Professor of *Materia Medica* has 50*l.*

9304. (*Dr. Sharpey.*) The Professor of Botany has assistance, I believe, only for three months in the year?—Yes. The Professor of Practice of Medicine is allowed 25*l.*, the Professor of Surgery 25*l.*, the Professor of Pathology 25*l.*, and the Professor of Medical Jurisprudence 50*l.*; so that we conceive that our assistants are miserably remunerated.

9305. (*Chairman.*) But the University does not possess any funds which will enable them to remunerate the assistants more sufficiently?—We are unable to do so.

9306. And you think it would be desirable that the Government should render further assistance in that direction?—I think it would be very desirable if we had some increased endowments for that purpose.

9307. I do not understand from your evidence that there is any special provision made at Edinburgh for original research?—I think I may say that there is no special provision made for original research in the shape of funds.

9308. Do you consider that a subject of importance?—I consider it a subject of very great importance.

9309. Can you suggest what would be the best means for making such provision?—I think that we ought to possess funds to enable us to procure all the best appliances and all the best instruments required in research. Then I think that if we could hold out pecuniary inducements to our students to pursue a scientific career, for say a few years after their graduation; if the University could offer them any inducement to remain about the University, carrying on scientific research, it would be a great advantage. The only prizes or scholarships in the University open to students and graduates in science and medicine are the following: The Neill Arnott Prize of 50*l.*, tenable for one year by a student of medicine; the Hope Chemistry Prize of 50*l.* per annum, tenable for two years; the Baxter Physical Science Scholarship of 60*l.* a year, tenable for two years; the Baxter Natural Science Scholarship of 60*l.*, tenable for two years; the Falconer Memorial Fellowship of 100*l.* a year, tenable for two years; the Syme Memorial Fellowship, instituted a few months ago, of the same value; and the Ettles Prize, of the value of 45*l.*, for the most distinguished medical graduate of each year. That is all that we have to offer.

9310. Are any of those endowments of recent date?—They are all, excepting the Hope Chemistry Prize, endowments founded during the past 10 years. The exact date of the Hope Chemistry Prize Professor Crum Brown will be able to mention; but the others are in fact since the Act of 1858, when the Scottish University Commission took the patronage and government out of the hands of the town council of the city of Edinburgh, and gave to the University an independent government.

9311. Do you think that there is any considerable probability that further endowments will be derived from private sources?—I think it is very probable that we shall occasionally receive additional endowments from private benefactors.

9312. Those subjects which you have last described to us you are of opinion cannot be provided for unless assistance is obtained from the Government, more especially with reference to provision for original research?—I see no prospect of it at this present time. There is one other point which perhaps I might refer to. I have spoken hitherto of our medical instruction and our appliances for it simply in connexion with our system of professional training, but there are various departments of knowledge which form a part of the professional training in medicine, which are also of importance in connexion with a general scientific education. More especially I refer to botany, chemistry, natural history, anatomy, and physiology. If we possessed proper buildings for teaching purposes, if we possessed proper appliances in the way of apparatus, and if we possessed sufficient funds to remunerate and retain about us a good staff of well-qualified assistants, I think that the University would be enabled to develope itself as a teaching body in connexion with affording general scientific instruction, much more so than it has hitherto been able to do.

9313. With regard to the assistants that you have spoken of, are they in general those who had been former students?—They are in general young graduates of the University, graduates who have gone through a distinguished career as students, and who have shown a special aptitude for the particular subjects that they are appointed to assist in teaching.

9314. Do they often hold the office for any considerable time, or usually for two or three years only?—Some of them for a short time only—one year—others for a longer period. Some get promotion elsewhere in the particular subject to which they have specially applied themselves. Edinburgh I think I may say has been a great training school for professors. The professorships in many colleges and Universities, not only in Scotland, but in England, Ireland, and the colonies, are filled by Edinburgh graduates.

9315. Although the emoluments are very small, are those posts in some respects considered desirable for young men as giving them facilities for training themselves to hold offices of more importance hereafter?—Undoubtedly they are looked after by the more able students.

9316. Have you had a difficulty in obtaining properly qualified assistants in any case?—I myself have never experienced any difficulty.

9317. Can you state whether it is so anywhere?—I am not aware that my colleagues have experienced any difficulty on that score.

9318. (*Dr. Sharpey.*) With regard to the anatomical museum, that is the property of the University, is it not?—It is the property of the University.

9319. How is it maintained?—It is maintained by a small annual grant from the general University fund, the sum of money granted being 167*l.* during the year 1869–70, and that is about the average sum granted to it.

9320. Making allowance for the want of space that you referred to, is it intended that it should be open to any student to inspect?—The anatomical museum is open at certain hours and on certain days every week to the students of the University.

W. Turner, Esq., M.B.

12 Feb. 1872.

9321. Besides yourself what other professors use the anatomical museum?—It is used extensively by the Professor of Pathology, by the Professor of Physiology, or Institutes of Medicine, by the Professor of Surgery, the Professor of Medicine, the Professor of Midwifery, and the Professor of Natural History.

9322. May specimens be carried into the class rooms?—Yes.

9323. You mentioned that in the summer there is instruction given in comparative anatomy; is that systematic instruction?—It is not systematic instruction, it is voluntary instruction on my part. I give no special ticket of admission, and I give no class certificate, but inasmuch as we have a valuable comparative anatomy collection in the anatomical museum, I consider it advisable to make use of it for teaching purposes. It may be well to state that comparative anatomy has always formed a part of the teaching of the Professor of Anatomy in the University of Edinburgh.

9324. I am aware that a comparative anatomy collection is part of the general anatomical museum; but supposing there were a distinct course given by a Professor of Comparative Anatomy, do you think that that would be a useful addition to the instruction given in the Edinburgh University?—Since the Natural History Chair was subdivided last year by separating from it geology and mineralogy, and allocating those subjects to a distinct professor, I believe that the Professor of Natural History is now enabled to devote himself especially to zoology, and that he teaches it from a comparative anatomy point of view. So that I should apprehend that the amount of comparative anatomy instruction given in the zoological teaching would complete what was necessary in the shape of a systematic course of lectures.

9325. But is the zoology a summer or a winter class?—At this present time there is instruction both in winter and in summer. The instruction in summer is a three months' course, and in winter it is about three months also, I think.

9326. And do you think there would be time to go over the subject of zoology sufficiently to include any comparative anatomy within that period?—It would not be possible minutely to go into complete analytical detail, but a sufficient amount of comparative anatomy might be given to afford to a student a good general idea of animal structure.

9327. Do any other class of students besides medical students take advantage of your instruction in comparative anatomy?—Not that I am aware of, because I do not give a special course. I do not issue a special ticket, and I give no certificate, in fact I have not been called upon by the University to do so.

9328. I suppose the students attending natural history are many of them not medical students?—I believe a number of what are called general students attend the natural history class.

9329. In the examinations referred to, who are the examiners?—The examiners for the degree in medicine are all the professors in the medical faculty, with three non-professorial examiners who are elected by the University Court, and who are paid by a parliamentary grant of 100*l.* a year each.

9330. Is a candidate examined by more than one examiner upon the same subject?—The rule is for two examiners to sit at each table, one of whom is, as a general rule, a professor, and the other a non-professorial examiner.

9331. The professor, I presume, examines in his own subject?—Yes, the professor examines in his own subject.

9332. The assessor is presumed, therefore, to know several subjects, seeing that there are only three associated examiners to a number of different subjects?—Yes; he is supposed to have a good general acquaintance with more than one department of medical science.

9333. For example, in an examination on botany, whilst the Professor of Botany was examining, there would be along with him another examiner *ab extra*, competent to judge of the attainment of the candidate?—Yes; but perhaps I might mention that many of my colleagues and myself also are of opinion that our system of examination would be improved if we had more than three non-professorial examiners specially qualified. We are by no means indisposed to receive additional examiners *ab extra*, supposing that any arrangement could be made for properly remunerating them.

9334. Supposing you had sufficient funds at your command, how would you apply them in the promotion of original research?—In the first instance we must have proper accommodation, that is essential. Then with the proper accommodation we should have certain funds for providing material. Take, for example, the subject of comparative anatomy; it would be necessary to obtain animals, and many animals are costly to buy; so costly, that an advanced student or a young graduate might not perhaps find himself sufficiently provided with funds to do so. I think it would be very important if we could go into the market and buy rare animals.

9335. (*Chairman.*) When you speak of original research, do you speak of its being pursued by the professors as well as by your students?—I think it of the very utmost importance that a professor should have a sufficient amount of time at his disposal to pursue original research in his own department.

9336. How far is that the case at present?—I think I may say that all of us are engaged in research, and that we strive as far as possible to get time for that purpose. I myself devote all my leisure to that object.

9337. (*Dr. Sharpey.*) With a very large class, such as you have, the aid of a highly-skilled assistant would enable you, would it not, to devote more time to original research?—It would be of very great importance to me to be able to obtain the services of more than one highly-skilled assistant, and, if an adequate salary could be offered, to retain them for some time.

9338. I suppose that a skilled assistant who contemplated remaining for a considerable time in that position would look forward to a professorship eventually?—He would esteem it as an admirable training school for a professorship. I myself was trained in that school.

9339. Supposing the means of teaching were developed to the extent that you contemplate or desire, could you turn the University of Edinburgh to any account in instructing teachers, either of elementary or of secondary schools, practically and solidly in science?—I think that if we had proper space and proper funds for providing assistance and the necessary material, we might in a very thorough and effectual manner give that assistance which you refer to.

9340. It might be partially paid for, might it not, by fees?—Yes. [*See* APPENDIX V.]

ALEXANDER CRUM BROWN, Esq., examined.

A. C. Brown, Esq.

9341. (*Chairman.*) You are the Professor of Chemistry, are you not, in the University of Edinburgh?—Yes.

9342. Will you in the first place state to the Commission the amount and the nature of the teaching of chemistry in that University?—I may divide this subject into three departments: firstly, lectures on elementary chemistry; secondly, practical teaching for medical students; and thirdly, practical teaching in the laboratory for those who intend to devote themselves more especially to the study of chemistry. The lectures upon chemistry extend over the winter five months, five lectures a week, at least 100 lectures in all. They are intended for students who have not studied chemistry previously; and although some students attend the course twice, they are adapted for those who have not studied the subject before. The subjects treated are, the chemistry of non-metallic elements, the chemistry of

A. C. Brown, Esq.

12 Feb. 1872.

metals, and organic chemistry, as far as it is possible in such a course to go into the subject. Besides those lectures there is a tutorial class in which the chief assistant gives instruction more of the nature of tutorial drill than it is possible to give in the regular lectures, taking up particularly the parts of the subject involving calculation, showing the students how to work chemical problems, and giving out exercises for them, which they answer and hand in before the next meeting of the tutorial class. Those tutorial classes are held for an hour once a week.

9343. And are they conducted by your assistant?—Yes. There are two or three written examinations in the session on the subjects treated of in the lectures, the results of which determine the honours' list for the class.

In the practical classes for medical students we have one session which we call the spring session, beginning in January, and comprising January, February, and March, and one summer session, comprising May, June, and July. The students meet for one hour a day on five days of the week, and they are instructed by one of my assistants, of course superintended by myself, but I do not give the instruction personally. He describes to them the operations which they are to perform, and then they go through the work themselves. The course includes elementary qualitative analysis, the determination of the composition of a salt containing one acid and one base; what remains of the session after this elementary course is devoted to the examination of the more important poisons, the detection of blood stains, the examination of urine for abnormal constituents, such as albumen and sugar. We always have time at the end of the course to go over a number of those additional subjects.

We have also a laboratory which is open for students intending to devote themselves especially to the study of chemistry. Beginners are required to go through a definite course of instruction, commenicng with the study of the chemical properties of the salts of the more commonly occurring metals. This knowledge is then tested and confirmed by its application to the detection of the ingredients of a number of substances, the composition of which is known to the teacher. These analytical exercises become progressively more difficult. When the student has shown himself thoroughly capable of analysing qualitatively with the requisite skill, he is introduced to the study of quantitative analysis. Here, again, the exercises are progressive in their difficulty. When the student has shown that he is capable of analysing with accuracy complicated substances, he would, if space allowed, be recommended to practise the preparation of chemical substances, on a somewhat large scale. Unfortunately the laboratory space is so small as to preclude any more than one or two from availing themselves of this most valuable means of chemical education. When the student has passed through the course described, he has gained sufficient skill in working and general knowledge of facts to admit of his following out any special line of investigation in which he may take an interest. This is left in a great measure to his own decision. If his only object is the furthering of his chemical education, he is entrusted by the teacher with the investigation of some chemical question. This he works out under the superintendence of the teacher, and thus acquires a knowledge of how to conduct original investigations. The students who come to the laboratory having previously had some knowledge of practical chemistry, fall into this course at the stage suitable to their attainments, which we ascertain by examination, and by seeing what they can do.

9344. Have the students who go into the second and third courses which you describe usually passed through the first course previously?—Yes, they all have, either in Edinburgh or in some other school. I do not admit a man to the laboratories unless he has attended some course of lectures on chemistry, but not necessarily in the University of Edinburgh.

9345. Will you give the Commission some information as to the number of students receiving instruction in chemistry?—I have obtained statistics for the last 10 years, including two years of my own, and eight years of Professor Playfair's occupancy of the chair, giving the number of students attending the lectures, the practical classes, and the laboratories. I have divided those attending the lectures into medical students and those who are general students. In the first year, 1861–62, comprising the winter session of 1861–62 and the summer session of 1862 (from November 1861 to July 1862), the number of medical students attending lectures was 99, and the number of non-medical students attending lectures was 64. The number of students attending practical classes was 72; the number working in the laboratory during the winter session of 1861–62 was 14; and during the summer session of 1861–62, 11. In the last year, for which I have complete data, which is the year 1870–71 (from November 1870 to 1871), the number of medical students attending the lectures was 178, non-medical students, 46; practical students, 140; attending the laboratory during the winter session of 1870–71, 10; and during the summer session of 1871, 10. The average attendance during the 10 years of medical students attending lectures is 125; of non-medical students, 54; attending the practical classes, 63; attendance on the laboratory during the winter session, 10, and during the summer session also 10.

9346. The medical students appear to have considerably increased during the period of which you have spoken?—Very much indeed; and the number of arts students, that is of non-medical students attending the lectures, has remained very much the same during that period of 10 years.

9347. What are the means which the University possesses for teaching chemistry in reference to the teaching staff?—There is a professor, and there are provided under the ordinances of the University Commissioners two assistants; but I have found it necessary, and Professor Playfair also found it necessary, to provide a larger staff of assistants in order to carry on the work efficiently. I have at present two assistants, who are paid partly out of the University fund and partly by myself, a lecture assistant, and a boy, who assists in the laboratory; four assistants in all, besides a laboratory servant.

9348. For the payment of two of those you must provide yourself?—Yes, for two of the assistants and the laboratory servant I provide entirely myself, and I add to the payment given to the others.

9349. What apparatus and specimens have you for lecturing and illustration in practical teaching?—There is a collection of old apparatus, mostly inapplicable to the purpose, which belongs to the University, the remains of old collections. There is also a collection of specimens for the illustration of lectures which was presented to the University by Professor Playfair when he retired from the chair. The remainder of the apparatus, both what is used in the laboratory for practical work and what is used for lecture purposes, belongs to myself. I purchased what belonged to Professor Playfair when I was appointed to the chair, just as he purchased the collections and apparatus of his predecessor.

9350. Then what Professor Playfair made use of is not the property of the University?—Only the specimens for the illustration of lectures; the apparatus was his private property, and is now my private property.

9351. Have you any other apparatus available?—No other apparatus is available, but specimens for lecture illustration I obtain from the Natural History Collection, and from some other collections in the Museum of Science and Art, under an arrangement which was made by the Department of Science and Art at the time that the Natural History Museum was made over from the University to that department.

9352. Are those collections conveniently situated for the purpose?—There is a bridge of communication between the University and the museum, which

A. C. Brown, Esq.

12 Feb. 1872.

might be made available for the purpose, but we rarely make use of that bridge, as there is seldom anyone in attendance to let us in at that door of the museum, and it is more convenient to go round by the street. I may perhaps mention that I have never had any difficulty in obtaining specimens from the museum, as Mr. Archer, the superintendent of the museum, is most courteous in giving all facilities in this way; but I have often difficulty in obtaining the precise specimen which I wish, from the fact that those in charge of the collection are not always aware of what the particular specimen is; they are not, in fact, scientifically educated persons.

9353. As Professor of Chemistry, have you a right to demand the use of any specimens that you require?—I understand that I have. I have never examined the documents in reference to that subject, but I was informed when I became professor that I had such a right.

9354. At any rate you have had no difficulty in obtaining any specimens that you require the use of?—No difficulty whatever, except as previously explained.

9355. Have you sufficient space appropriated for the department of chemistry?—No. I drew up for the use of a committee of the Senatus a report in reference to that subject, in the prospect of a new building being obtained for the accommodation of the medical department of the University. I drew up a report with reference to the amount of space, and an abstract of it is embodied in the report which has been laid before the Commission. I have it more in detail as to the number of rooms necessary, and the precise size of each room, if it be necessary to mention it.

9356. If you had the space stated in this report you would have all the accommodation that you think necessary?—Yes; I think that would provide all that is required in the chemical department. I wish to mention with regard to the space that we have at our disposal, that not only is it inadequate in the present building, but it is most inconveniently situated. The room which is used for the laboratory was never intended for the purpose, but I believe was built as a room for the professor to make preparations for illustrating his lectures. It is dark and ill-ventilated, and altogether unsuitable for the purpose. With regard to the practical classes, the students have increased so much in number, from 72 at the beginning of the decennial period to 140 now, that the accommodation is altogether inadequate, so much so that I have been urging the University authorities to grant me any space whatever. I have even suggested a shed in the quadrangle, or the use of a room which is at present used as a refreshment room, as an increase to the accommodation.

9357. For that class of students I suppose that a considerable amount of space is very desirable?—Yes.

9358. Will you state to the Commission what salaries are paid to your assistants?—I have two high-class assistants, and I may mention that one of them lectures for me to-day, and will lecture for me to-morrow, merely to show that he is quite capable of taking that position. I have two assistants of that class to whom I pay 150*l.* a year each. The class assistant's salary, which I pay, varies according to the class of man whom I can obtain; to the class assistant whom I had when I became professor I gave 50*l.* a year. My present class assistant is only a beginner at the work, and I give him only 25*l.* a year, but I shall probably increase his salary. The junior assistant, who is in fact assistant to my head assistant, receives 10*s.* a week during the time that he is engaged, which is about 40 weeks during the year, making about 20*l.* a year. I pay the laboratory servant 54*l.* 12*s.* a year. Of that amount paid for salaries, 200*l.* is supplied from the general University fund under the ordinances.

9359. The whole amounting to nearly 400*l.*?—Yes, it was rather more than 400*l.* the first year, and now it is rather less than 400*l.*, 200*l.* of which is supplied from the University fund; the rest falls upon myself.

9360. Are there no funds distinctly given by Parliament for this purpose?—No; the sum of 200*l.* is paid from the general University fund by the direction of the ordinances of the Commissioners.

9361. There are certain other expenses, are there not, attendant upon your lectures?—Yes; there are expenses for keeping up the supply of apparatus, and for substances used in class experiments, in the practical classes, and in the laboratory; I have estimated the amount on the average of two years at about 140*l.* a year for apparatus and substances. I have a grant from the University fund of 100*l.* a year for that purpose.

9362. That grant, therefore, is not sufficient practically for all your purposes?—No, it is quite insufficient.

9363. Are you of opinion that further means ought to be at the disposal of the University for the teaching of chemistry in two points of view?—Yes, it is necessary in the first place from the point of view of the Medical School. Originally the Chair of Chemistry was a medical chair, the first Professor of Chemistry having been Professor of Medicine and Chemistry. Professor Hope was the last Professor who was Professor of Medicine and Chemistry. On his death the title of the Chair was altered to that of Chemistry; but it is still a Chair in the medical faculty, and although it is becoming more and more important in other respects, its primary function in the University of Edinburgh is the training of medical students. For that purpose it is necessary to have more complete and more perfect means of teaching, and especially of practical teaching. This is now universally recognised as being of great importance, but has been so recognized only within a comparatively short period. The accommodation which we have and the means at our disposal for practical teaching are quite inadequate, It would be necessary, in order that we should keep up what is required for complete medical education, that we should have additional space and additional assistance to carry out the practical teaching of the medical students. For general students, for the students who are not studying for the profession of medicine, I think it would be desirable that a short course of practical chemistry or of analytical chemistry should be arranged, so that students who do not intend to become professional chemists might still have the means of attaining a considerable amount of practice in chemical manipulation. At present the University laboratory is able to accommodate about 12 students only at a time, and I am quite sure that if we had additional space the number might at once be more than doubled. I have never been obliged to turn away students from the laboratory, but I have had to dissuade them from entering it, and have asked them to put it off until they should have a little more knowledge of the subject. I have always thought it desirable that beginners should have some practical instruction, and that we should not wait until they have had five months' lecturing before they begin to work themselves; but I am unable to admit them because I have so many students of a more advanced class, whose claims upon the space in the laboratory are greater.

9364. In the proposed new buildings is provision made for a very considerably enlarged laboratory?—Yes; in the estimates which I sent in as to space I have made an estimate for 40 laboratory students. I scarcely think that at first we could count upon so many, but I do not think that it would be safe to build any laboratory with accommodation for fewer.

9365. Do you find that the number of persons desiring to study chemistry who have not an intention of entering the medical profession is much on the increase?—I am not very well able to give an opinion upon that subject. The number of non-medical students attending the lectures has been pretty much the same during the last ten years; and as to the laboratory I am not able to judge, because it is almost always quite full, and those students who work in it are, I may say, all non-medical students. We have none or scarcely any medical students attending the laboratory.

A. C. Brown, Esq.

12 Feb. 1872.

9366. (*Sir J. P. Kay-Shuttleworth.*) Is there any practical instruction in connexion with the Chair of Medical Jurisprudence?—The Professor of Medical Jurisprudence has a laboratory for his own use and that of his assistant; advanced students occasionally carry on researches in it, but I am not able to speak positively with regard to that subject.

9367. (*Chairman.*) Are you of opinion also that additions are required to the University means with a view to original investigations?—Yes. I may mention in reference to that, that before I became professor, while I was what we call an extra academical lecturer, which corresponds to the *privat docent* in German Universities, at the laboratory which I had at that time I had more opportunity for carrying on original investigations than I have at present in the University; because our space is insufficient.

9368. Where had you that superior accommodation?—It was in a house which I, along with some other lecturers, hired for the purpose, but not belonging to the University. Advanced students often ask me to guide them in the choice of investigations, and I have always in advising them to consider the expense of the investigation as well as its difficulty. I should often be better able to select an investigation which would suit their knowledge and skill, did I not know that it would be difficult for them to defray the expenses of purchasing the substances necessary for the investigation.

9369. Can you specify in somewhat greater detail the means that you think desirable with a view to original investigations?—First of all we require more space, and not only more space, but more subdivision of space for the purpose, so that different forms of work may be carried on in different rooms. In reference to that perhaps I might mention, although it does not exactly fall under your grace's question, that we have but one room in which to carry on analyses, the preparation of specimens, and furnace operations, three departments of work which ought certainly to be accommodated in different rooms.

9370. Was space for those subjects contemplated in the buildings which it is proposed to erect?—Yes. Then as to pecuniary assistance, I think it would be very desirable to have a fund, and perhaps it would be best put at the disposal either of the Senatus or of the professor, to assist advanced students and others in carrying on investigations, so that the expense of original investigation might not necessarily fall upon the investigator.

9371. Can you name any sum that would go a good way towards accomplishing an object of this kind. I mean in the way of grants for assistants and for apparatus?—At present I spend about what I think would be proper for assistants and apparatus. What I spend upon that would probably be not far from what it ought to be, but if I had funds I certainly should spend more.

9372. Especially in apparatus?—Yes, I think so, but I have not considered the question from the point of view of an unlimited purse.

9373. When you speak of additional lecturers in special departments, how many do you think you would require?—Professor Playfair in the summer gave lectures on special subjects, and I have it in contemplation to do the same; but I believe it would be much better if we had special lecturers to supplement the course. We have at present a Professor of Engineering, and I think that if we had subsidiary lecturers upon applications of Chemistry, such as metallurgy, it would greatly improve the teaching power of the University in the engineering department. It seldom happens that a Professor of Chemistry is equally well up in all departments of the subject; and I think it would not be difficult to get special lecturers upon such subjects as metallurgy, agricultural chemistry, and physiological chemistry, who would be able to give special courses of lectures upon these subjects for those who intend to devote themselves to those branches.

9374. Would you regard such lecturers as permanent officers of the University, or do you only contemplate engaging occasional lecturers for the purpose?—There is at present a committee of the Senatus considering the subject, but they have not yet reported. The difficulty is to obtain proper men; and some of those lectureships must necessarily be vacant from time to time from the impossibility of getting a man specially qualified to lecture upon the subject; but if we were always able to secure and to keep suitable lecturers, we should wish those lectureships to be permanent.

9375. You further think, do you not, that it would be desirable also that you should have some funds from which to defray the expenses of researches?—Yes.

9376. Could any considerable amount of funds be expended in that direction?—That would depend a good deal upon the number of advanced students whom we could employ in this way. In considering this question, we may look primarily, either, first, to the advancement of science, or, secondly, to the education of the students. As the University is a teaching body, I have chiefly kept in view the second of these objects, the attainment of which will, to a certain extent, secure the first also. The amount which we could expend on this form of higher chemical education, would depend on the number of advanced students willing and fit to take advantage of it, and we cannot at present form anything like an accurate estimate of what that number would be.

9377. (*Dr. Sharpey.*) Might not the fees paid by those who attend such special courses go a good way to defray the expense of them?—I believe they might to a very large extent, although it is desirable that the lecturer should not be wholly dependent upon his fees, and be obliged to defray his own class expenses.

9378. You have estimated the space for your practical laboratory; what amount of superficial space did you allot to each worker?—Five feet by six feet, including standing space, table, and space of central passage.

9379. (*Chairman.*) Will you now proceed to describe to the Commission the extent and character of your examinations in chemistry; first of all, as regards degrees in medicine?—Every student is examined at what we call the first professional examination (an examination which is held at the end either of the second summer or the second winter session) in Chemistry, Botany, and Zoology, and the examination is by written papers, practical examination in the laboratory, and by oral examinations. The examinations in chemistry are limited to the principles of chemical action, as illustrated by the compounds of the non-metallic elements and the more common metals, the classification of organic substances, the principles of organic analysis, the general characters of the chief groups of organic substances, and a more detailed knowledge of the properties and reactions of substances interesting from a technical or medical point of view. The examination is calculated to test the knowledge which a student may reasonably be expected to have acquired by intelligently following a five months' course of lectures upon chemistry, and attending the practical class for three months. The examination in practical chemistry is limited to the detection of the constituents of salts, each containing only one acid and one base. The oral examination is especially important, as it enables the examiner to detect "cram," and to discover whether the candidate has a sound and intelligent knowledge of the subject, or has merely got it up from books.

9380. Are the questions for the written examination prepared by yourself?—Yes, they are prepared by myself, subject to the approval of the Faculty of Medicine, and the examinations are conducted by myself and one of the non-professorial examiners in the manner described by Professor Turner, and I may say that we all desire an increase in the number of non-professorial examiners, because, as they are not appointed as examiners in any one department, it must frequently happen that no one of them is specially acquainted with the subject of chemistry.

A. C. Brown, Esq.

12 Feb. 1872.

9381. But the want of funds is an obstacle to that course being adopted?—Yes.

9382. Do the examinations for degrees in science differ in any respect from those for degrees in medicine?—Every candidate for a degree in science must pass the first Bachelor of Science Examination. The examination in chemistry (forming part of that examination) is very nearly the same as that for medical students at the first professional examination; the standard is, however, somewhat higher. At the second Bachelor of Science Examination, the candidate is allowed to select one of several departments. If he selects the Department of Experimental and Physical Science, he is examined in physics and chemistry. The examination in chemistry includes the more difficult parts of inorganic chemistry, organic chemistry in greater detail than in the first Bachelor of Science Examination, and the relations existing between the chemical constitution and the physical properties of substances. A Bachelor of Science may present himself for examination for the degree of Doctor of Science in any one of a considerable number of subjects, one of which is chemistry. We have not as yet had a candidate for the degree of Doctor of Science in Chemistry, as the degree has only been recently instituted; but in the notice in the calendar it is stated that the examination is to be a searching one upon all departments of chemistry, and especially upon one selected by the candidate.

9383. Are all the degrees in science recent institutions?—Yes.

9384. (*Dr. Sharpey.*) You are a Doctor of Science of the University of London, are you not?—Yes. At that time there was no degree in science in Edinburgh.

9384*a*. I believe you were the first to take that degree?—Yes.

9385. (*Chairman.*) Are there any other points upon which you would like to make any additions to your evidence?—There is one point to which Professor Turner has alluded, in reference to which I wish to make a statement, viz., the Hope Chemistry Prize. The late Professor Hope, Professor of Chemistry in the University of Edinburgh, who died in 1844, bequeathed a sum of about 1,000*l*. to the University to found a prize or prizes for the purpose of furthering the study of chemistry in the University. For some time the income of this fund was applied in payment of the laboratory fees of the first four students in the honours' list of the general class of chemistry; the first two to be styled senior Hope scholars, and to work for two sessions in the laboratory: the second two to be styled junior Hope scholars, and to work for one session in the laboratory. About three years ago the Senatus, considering that students to whom the scholarships had been awarded did not always wish to work in the laboratory, converted the prize into a scholarship to be competed for biennially, the competition to be open to students not more than 25 years of age, who had worked for at least two sessions in the laboratory. The successful candidate is to spend the succeeding academical year in working in a laboratory or laboratories, under conditions approved by the Senatus, and to receive 100*l*. in two half-yearly payments of 50*l*. each.

9386. (*Chairman to Professor Turner.*)—Does anything occur to you which you would like to add to the evidence which you have given?—I should not like the Commission to think that we are not very desirous of some pecuniary aid. We are very desirous of pecuniary aid.

9387. Do you want aid for other purposes besides building purposes?—Yes. The University of Edinburgh is miserably poor, and we are cramped on all sides by want of funds.

9388. You want an annual grant in addition to a grant for buildings?—Yes, we should like an annual grant. We are now developing our system of teaching, and I think that the statistics which I have given you as to the great increase which has taken place in the number of our students during the past five years show that the University is really doing good work in the way of scientific teaching; and we feel that unless some additional means is given us for affording proper accommodation and proper appliances to those who come to us for instruction, it may very materially affect our future prospects.

9389. I think I understood you to say that you had from one source or another about 1,870*l*. a year from the Government at present, namely, 1,370*l*. for professors, and 500*l*. for general purposes?—Yes; the Government give us 500*l*. for keeping our buildings in repair.

9390. Are those two sums the whole of the assistance that you get from the Government?—The sum of 1,370*l*. is the whole of the assistance that specially appertains to the departments of science concerned in medicine.

9391. Do other departments of the University get any considerable assistance from the Government?—The Natural Philosophy Department has a parliamentary grant to the Professor of 180*l*. a year, and to his assistant of 100*l*. a year. Practical Astronomy has a grant of 300*l*.; but the Professor of Practical Astronomy is also the Astronomer Royal for Scotland, and I think that he holds that his salary is given to him more in virtue of the duties which he performs as Astronomer Royal than as Professor of Practical Astronomy; he has no separate salary as Professor.

9392. (*Dr. Sharpey.*) Has he any students?—One student was returned as receiving instruction in 1869–70. The Professor of Agriculture gets a grant from the Government of 150*l*. yearly, the Professor of Engineering of 200*l*. yearly, and the Professor of Geology of 200*l*. yearly. Several of the Professors in the Faculties of Arts, Law, and Divinity also receive parliamentary allowances.

9393. The increase in your number of students increases your emoluments, does it not?—Yes, the emoluments of individual professors. Of course it also adds to the income of the University as far as regards the sum paid as matriculation fees.

9394. But I presume that the aggregate income of the University, whatever it is applied to, must be increased by an increase in the number of students?—Yes, but still it is not very great, because a student only pays a matriculation fee of 1*l*. to the University fund.

9395. A Professor receiving fees from twice the number of pupils could afford to have twice the number of assistants?—Yes.

(*Professor Brown.*) Perhaps I might be allowed to observe, in reference to the general fund of the University, that while we are very glad to have such new Chairs as the Chair of Geology and the Chair of Engineering provided by the generosity of private persons and the Government, it must be recollected that every additional Chair which is founded in the University makes an additional demand upon the general fund, which is not proportionately increased by the number of students attending that class, as the amount contributed by each student to that fund does not depend on the number of classes which he attends.

9396. (*Chairman, to Professor Turner.*) You stated that funds are wanted for other purposes besides building. May we understand that they are principally required for the purchase of apparatus?—I would strongly urge that something should be done in the way of properly remunerating our assistants. Several of them receive the very small sum of 25*l*. a year, and that is obviously altogether inadequate to be paid to a man of education who has already expended a large sum on his own scientific and professional training. [*See* APPENDIX V.]

The witnesses withdrew.

Adjourned to Friday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 16th February 1872.

PRESENT:

WILLIAM SHARPEY, ESQ., M.D., SEC. R.S., IN THE CHAIR.

GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S. | HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

PETER GUTHRIE TAIT, Esq., examined.

P. G. Tait, Esq.

16 Feb. 1872.

9397. (*Chairman.*) You are Professor of Natural Philosophy in the University of Edinburgh?—I am.

9398. When were you appointed to that office?—I was appointed in 1860.

9399. In succession to the late Principal Forbes?—Yes.

9400. Will you state to the Commission the instruction at present given in natural philosophy in the Edinburgh University?—I have two classes to which I lecture. To the first I give over 100 lectures on the whole subject of natural philosophy, carefully explaining and exhibiting the experimental foundations of the subject, and the connexion of the various branches; that is the junior class, and numbers somewhere about 175 students on the average. My second course is to a higher class of students, or students who have attended the junior class for the two or three years preceding. To that class I give three lectures a week; so that in the course of the winter session I give more than 60 lectures to it. Those lectures are upon the applications of the higher mathematics to physical science, treating generally the whole subject of dynamics, the mathematical theory of heat; not only the theory of heat as it was understood by Fourier (the conduction of heat, &c.), but the modern dynamical theory of heat, and also the theory of electricity. In addition to those sets of lectures which are given by myself, there are tutorial lectures by my class assistant. Those tutorial lectures are given whenever I find a part of a subject which I have not time to develope myself, and when he can be for the purpose spared from his other occupations in the laboratory.

9401. Those would be, I presume, to the junior class?—Yes, to the junior class simply; as a rule I cannot always trust my assistant to give them to the senior class.

9402. Are there examinations of the class from time to time?—I hold fortnightly examinations of the junior class. Those examinations are introduced as much with the view of teaching the students as with the view of ascertaining their proficiency; in fact I find that the use of examinations, not so much for the purpose of giving marks, or anything of that kind, but of finding out the points which the students have not properly understood, is absolutely essential in connexion with teaching; in short I try to find out how far they understand, in order that I may know what I must teach them next, or whether I must go back again.

9403. Are those oral examinations?—They are oral in the sense that the questions are given out orally; but it is quite impossible to examine so large a class orally without taking a whole day to do it, and therefore what I do is this: I prepare a paper containing about 12 questions entirely upon subjects which have already been to the best of my ability thoroughly explained in lecture. If anything in addition to what has been given in lecture is introduced, it is of the nature of arithmetical or simple mathematical application. Those questions are given out orally by me at intervals of five minutes each, and I expect an answer to each in a single short, clear, written sentence. I always endeavour to frame the question so that it admits of an answer in that form, and I refuse altogether to look at or correct, or give any credit for answers of the nature of essays.

9404. In that way therefore you address questions to the whole class and receive written answers to them from every student?—Yes. In addition to those fortnightly examinations, I have a couple of special examinations taking place, one towards the middle of the session, and the other towards the end of the session, and occupying a much longer time, in which the subject of examination is one which has been prescribed for the students' private reading. For instance, as one example of the nature of a subject prescribed in that way, I may mention the first three sections of Newton's *Principia*. It is quite impossible for me to introduce them in my lectures, because I have so much to do with the purely physical part of the subject; but still I consider it one of the very best pieces of training a student of natural philosophy can possibly have, and therefore I prescribe it for home reading, and examine on it, and give perhaps three or four hours' examination to it. So far for the examinations. Now I come to another and not less important part of the teaching in Edinburgh, and that is the physical laboratory.

9405. When is that open?—It is open during the winter and summer sessions, that is to say, practically about nine months in the year, six months in the winter and three months in the summer.

9406. During how many hours a week is it open?—Somewhere about 25 hours a week, that is to say, it is open at least five days a week, from about 10 to 3 o'clock each day. I cannot say that I am satisfied with the amount of time that it is open, but the assistance that I have at present does not permit me to keep it open longer.

9407. What class of students attend the laboratory?—I have made the laboratory open to all comers, limited of course by the number of students which my assistant and I can look after, and which my space can accommodate.

9408. How many do you find attend?—It is impossible for me to accommodate more than 10 or 12 at a time in the space at my disposal. I have had to refuse applications from a great many persons.

9409. Those 10 do not alternate with any other 10, do they?—No; they are free to spend their whole time in the laboratory when it is open each day, and thoroughly to devote themselves to their work.

9410. How is the expense of this defrayed, is there a special fee?—There is a small fee of two guineas from each student, but of course I need not say that that two guineas is quite inadequate to pay for the mere chemicals and other materials used by each student.

9411. Have you to supply the materials?—Yes, I have to supply the materials, but the fund that I draw upon for the purpose is what I get for class expenses. I may mention with regard to the teaching in the laboratory, that with the help of my assistant I put each student as he enters the laboratory through an elementary course of the application of the various physical instruments, the primary ones. For instance, I begin by practising them in measuring time, estimating small intervals of time, then measuring very carefully by the micrometer and spherometer, length, angle, curvature; and by other appropriate instruments, temperature, electric current, electric potential, and so on.

9412. And then are they capable of being set to work on special subjects under your direction?—When I find that they have sufficiently mastered those elementary parts of the subject I allow them to choose the particular branch of natural philosophy to which they wish to devote themselves, and when they have told me that, it is not by any means difficult to assign

P. G. Tait, Esq.

16 Feb. 1872.

to them, if they carry it out properly, what may be excessively useful and even valuable work.

9413. Will you point out some of the difficulties in the way of accomplishing those objects?—My principal difficulties may be classed as those of deficiency of space and deficiency of assistance. I have other difficulties, but these I shall mention in the course of my examination. The first great deficiency, and the one which is felt through the whole University, and not merely in the department of natural philosophy, is the extreme poverty of the University itself. The only resource available is the small sum which is acquired mainly from matriculation fees, and so on, and which has to be divided amongst almost as many applicants as there are professors in the University. The consequence is, that in addition to the 100*l.* a year which by the ordinance of the University Commissioners has to be paid for my class expenses out of that fund, I have only been enabled to get about 25*l.* a year. Even this is subject to possible diminution in the event of some sudden demand on the funds of the University.

9414. We have had evidence before us as to the principal funds of the University, and the application of the income derived from them, from which it appeared that that income was appropriated already?—That is so; but when there is a large number of matriculations, as, for instance, during the last three or four sessions, when matriculations have been rising steadily, of course this general college fund, which depends mainly upon the number of those matriculations, has been rising along with them, and medical graduation also has been rising, and that constitutes a feeder.

9415. Is there not an income from the property of the University?—There is an income from property, but the revenues from that have all been appropriated by the Commissioners, so that what we rely upon is mainly or wholly I may say the chance additions by the increase of the number of students from matriculation and graduation fees.

9416. The want of funds being one serious difficulty, as you have mentioned, there is a great want of room, is there not?—Yes. Although the want of space of course comes practically in the long run to a question of want of funds also, I may mention that as regards space I am perhaps worse off than any professor in the University of Edinburgh. For nearly eight years I was exceedingly desirous to obtain space for a laboratory. I saw that it was excessively desirable that such a thing should be established in Edinburgh, but I could not get space until 1868, and then the space which I got was a small class room which had come to be disused, entirely unsuitable, or at least by no means very suitable for almost any class of experiments, and that is practically the space to which my laboratory is confined at present. I may mention to the Commission that Dr. Sharpey, when he saw my accommodation, advised me to have it photographed in order to bring it effectively before the Commission. When I have more students than eight or ten attending the laboratory at once it is absolutely essential, in order to accommodate them, that I should have some of them working amongst my collection of apparatus, and others working in my class room whenever it can be put at their disposal; and the superintendence of groups of students scattered about, with stairs to ascend, and passages between them, is a matter of considerable difficulty, and adds materially to the labour of teaching.

9417. It would seem that you have not only a difficulty in the way of receiving students in sufficient numbers, but as to the kind of experiments that you are able to carry out?—Entirely so; it is impossible for me to allow one man alone to make experiments, for instance, in a darkened room, because unless there were a special room which could be darkened for him, his darkening of the room for his own experiments would prevent any others continuing their experiments. Then my rooms, such as they are, are so close together that if I wished to perform experiments on diamagnetic bodies, where a powerful electro-magnet is required, the moment I set to work the galvanometers (as well as electrometers and other instruments depending on magnetic force) in all the rest of my rooms are disturbed, so that it is impossible to carry on investigations with them.

9418. If you had funds at your disposal, have you formed any opinion as to the most advisable mode of extending your space?—I should have no difficulty whatever in extending my space provided the University obtained funds enough to remove from the present University buildings the departments of anatomy and chemistry. Once those were removed from the present buildings there is the whole space occupied by anatomy in immediate contiguity to my present department, and in it I should have no difficulty in getting the amount of space required. Whether it would be in the best possible form or not is another question, but as far as space is concerned the removal of the department of anatomy would furnish me with an ample supply.

9419. So that besides the advantage that would result to the anatomical and chemical branches of the University by such removal, it would be a great advantage in other departments, by giving them additional space?—Yes, certainly. At present I may mention, in addition to what I have said about the want of space, that I have not only utterly inadequate space for my laboratory but barely space for my collection of instruments, and that in trying to keep my instruments as well up to the advancement of natural philosophy as I can, every new addition prevents my ready access to what is already there; in fact my instruments are in two or three places piled in strata about the room, and the additional labour of finding what I want at a moment's notice forms of itself a very serious inconvenience.

9420. You are also very much inconvenienced, are you not, by the want of proper assistance?—That again is a source of excessively unnecessary labour to myself, owing to the small amount of money which I receive for the payment of a mechanical assistant. I am not speaking of teaching assistance, but simply of assistance in keeping in order and setting up for experiment my apparatus. My difficulty in that respect is very great, but that again is merely a question of money. The mechanical assistant whom I have at the present moment is a man between 70 and 80 years old, who I may mention was in Sir John Leslie's service. He was doorkeeper when Sir John was Professor of Mathematics in the University of Edinburgh, and served him as mechanical assistant the whole time he was Professor of Natural Philosophy; and he served the whole or the principal part of his time with Principal Forbes in all his experiments, and he has served me since my appointment to the Chair. This is his 58th session in the University, and he is at present the sole mechanical assistant that I have, seeing that his son is temporarily disabled.

9421. He is paid by the College, is he not?—Yes, he is paid out of the same fund as that from which I get 100*l.* a year for class expenses.

9422. Have you any teaching assistant?—I have a class assistant, and I have already alluded to his giving tutorial lectures. He helps me not only by giving those tutorial lectures, but also by superintending the laboratory when I cannot be present myself; and besides that by relieving me of the excessively tedious work of looking over the answers to the examination papers. In the course of his looking over those answers to examination papers merely, he has on the average about 1,500 answers to examine once a fortnight. Then he spends the greater part of five hours each day in the laboratory, in addition to what tutorial lectures he is giving for me at the time.

9423. How is he remunerated?—He gets 100*l.* a year from the exchequer. I may mention that when you contrast the amount of work which he has to do for me with the pay which he receives, it is not at all wonderful that during the short period that I have had such an assistant I have had almost every second or

P. G. Tait, Esq.

16 Feb. 1872.

third year to train a new one, because the salary is utterly inadequate to the work expected of him.

9424. Does the fact of having assisted you for a considerable time in that capacity of teaching serve to advance the prospects of a young man?—I should say that under all circumstances the fact of having given really good service in the University in such a capacity would be of very great value to a young man, especially in Scotland, where the nature of the occupation is understood. I may mention that one assistant who, to my great regret, has lately left me, is now a professor in a Scottish college, although his subject is not natural philosophy. And one of my former laboratory students is already an assistant in the Royal Observatory of Edinburgh.

9425. Is it not a consequence of so much work falling upon the professor that he has not sufficient leisure for original work?—When matters are at the best, I have very little leisure for nine months in each year; but at the present moment I may say that I have absolutely no leisure at all. For, in consequence of the son of my mechanical assistant being laid up with small-pox, and not permitted to come back to assist me for perhaps another month, during the whole of that time I shall, with the assistance of this old man, have to prepare all my arrangements for class illustration myself. I may say that it is hardly possible, without a large sum, to hire a really trained assistant; no improvised assistant would be capable of giving me the least help, and therefore during the temporary disablement of my own assistant I must simply do his work myself as well as my own. It would take at least two months or more of training before I could trust a man with the apparatus.

9426. What allowance is made by the University for class expenses?—It is not made directly by the University, but 100*l.* was ordered by the Commissioners to be paid from the general University fund. I have since, after repeated applications, managed to obtain an additional grant of about 25*l.* a year.

9427. That includes, does it not, the purchase of new apparatus?—Besides the purchase of new apparatus, and keeping in repair of the extensive collection already acquired, it includes such items as coal, gas, and various other working expenses.

9428. What, in your opinion, ought to be the position occupied by the University in science teaching?—My opinion upon that subject is that the University should teach the principles of natural philosophy in full detail, and also the general nature of the applications of the subject; and, in addition to that, it should give instruction in the use of apparatus and the modes of conducting experimental research. A student prepared by such instruction is ready at once to take up any specialty, and will fall into the routine work required with very little difficulty.

9429. What is your opinion with regard to teaching technical work?—The University I think had better not attempt teaching technical work. It might be done to a certain extent in the Engineering Department, in such branches, for instance, as telegraphy, and so on, that come under the head of engineering; but technical work as a rule had far better be done in a workshop, or in an engineer's office.

9430. The University limiting its instruction to what is preparatory?—Yes, to that amount of scientific knowledge, be it extensive or not, which is absolutely necessary to every workman whether of the highest or the lowest class, that amount of knowledge of his subject which is necessary to render his labour intelligent, in order that the man should not do things by mere rote, but that he should know the reason why he is doing so and so.

9431. Have you formed any opinion as to the character that should be assumed by technical schools?—I have yet to learn that technical schools can in any case teach what cannot be at least as well taught, if not better taught, in a workshop or manufactory. I am certain of this, however, that if there be subjects which such schools can teach as well as they can be taught in a workshop or manufactory, those are simply applications of natural philosophy, not parts of the science. It would be vain to expect these schools to attempt to teach the science itself as distinguished from its applications, not merely vain on account of the extreme deficiency of men who can teach properly the elements of science, but on account of this, that what is wanted is that men before going to learn anything technical should understand thoroughly if it be but the merest elements of the science which they wish to apply. It is in a University that such instruction should be given, and that being done, there is comparatively little difficulty in doing the rest.

9432. Do you consider that the Universities in Scotland might be advantageously employed in instructing in science the teachers generally of elementary and secondary schools?—I consider that all teachers, and especially teachers of science, ought to be instructed by a teaching University; that the Universities of the kingdom ought to be the instructors of teachers, in addition to the other instruction which they give.

9433. (*Professor Smith.*) Do you mean expressly to include the teachers of elementary schools?—Especially the teachers of elementary schools. I conceive that unless a man has thoroughly learnt the elements of science, not using the word contemptuously, because the elements are sometimes the hardest part of a subject, unless a man has been thoroughly taught the elements he should not be accredited as a teacher.

9434. (*Chairman.*) Do you think that the Universities should also afford facilities for the scientific instruction required by the various classes of artisans?—Most certainly they ought so to do; but with the funds and assistance at present at the disposal of the professors it is absolutely impossible that they can do so. I have no doubt that when properly undertaken it would be exceedingly beneficial to the country that they should do so; but it is simply a question of want of funds, want of assistance, and want of space.

9435. Do you consider that they should be enabled to advance science by offering facilities in their laboratories for original research?—Certainly. I understand that one object of this Commission is to consider the advancement of science; and I am certain that science cannot be better advanced than by offering facilities in a University under proper supervision for original investigators. Those facilities may be absolutely priceless in the results which they may produce; but of course, in order that they may be afforded, it is necessary that the Universities should be furnished with laboratories and with proper assistance, and have the means of defraying the expense of investigation.

9436. You know of no other source from which the means could be obtained for such an object except by grants of public money?—We can hardly look to societies or to associations like the British Association for the amount of money that would be required; and the endowments given by private benefactors are usually in the form of the establishment of professorships, scholarships, and bursaries.

9437. Will you go on to state what you consider would be requisite generally to enable the University of Edinburgh to take and hold the position that it ought to do?—I begin by saying that I suppose there is no chance of the creation of an additional Chair in the subject of natural philosophy. Indeed, my own opinion is that the whole department of natural philosophy in each University ought to be under the direction and control of one man.

9438. Might there not be highly competent assistant teachers or assistant professors under him?—Yes; it is in that way, I think, that the department should have its teaching power extended. It is absolutely impossible for one man with such assistance as I have to do properly the work entrusted to me, even if I leave myself no leisure whatever for mathematical or experimental research, so that additional assistance to the extent of one tutorial assistant, at the very least, and one mechanical assistant, is required.

9439. What would be the duties of the professor then?—The duties of the professor then, besides the

P. G. Tait, Esq.

16 Feb. 1872.

general supervision and direction which he would exercise, would be to teach fully the principles of the subject, and hand the students over to his assistants for the mere details and applications and examples.

9440. It is far more difficult, I presume, to find one man who can teach the principles soundly than to find numbers who can teach the details of the science?—From my experience I am thoroughly convinced of the fact that for each one man who can teach the principles of such a science as natural philosophy, it is quite easy to find hundreds who can teach the details. When a man teaches as a professor should do, in dealing with the principles of science, his lectures although elementary are not to be considered as popular lectures. They ought to aim at thorough teaching in the highest sense of the word, and not at amusement combined with information.

9441. Have you anything further to state on that head?—I should say generally, summing up my views upon the subject, that a professor should be in the position as it were of architect, and not of mere hodman or bricklayer, except on emergencies such as that which is occurring at present in Edinburgh. Then I should add, that it is not merely the principles but also the highest departments of the science that should be taken in hand by the professor. When students apply for the highest applications of mathematics to natural philosophy, as a rule the assistants would be unable to furnish them; the professor should therefore be able to give instruction in these also, for in reality the difficulties of teaching natural philosophy are of two kinds, one in the very elements of the science, and the other in its highest branches. I may say that if I could have afforded it I would at once long ago have engaged additional assistance at my own expense, not to save me work, because I should probably work harder in consequence, but simply to enable me to be more useful to the University and to science than I possibly can be while engaged as I am at present. But I submit that even if I could have afforded it this is not an outlay which I should be left to defray.

9442. And you consider that the emoluments of the professorship are not at present adequate to compensate the professor for his labour?—Far from it. I did not mention that at first, because I consider that there are so many other pressing wants; but having already referred to these, I may mention with reference to the professor's income that a salary of about 200*l.* a year, with a fee of three guineas for each student, and with no official residence, is certainly not a liberal allowance for the professor of a subject of such magnitude and importance, with so large a number of students, and in the Metropolitan University.

9443. Have you formed any rough estimate of what would be the expense of extending and fitting out your laboratory in a way that would be suitable, supposing space were obtained suitable for your purposes?—I can give no information to the Commission as to the point of the expense of fitting up the buildings; that, I presume, they will get information upon from other sources. But with regard to the sums necessary for the purpose of improving and extending the teaching, and giving greater facilities in the laboratory, and so on, I am prepared to state, as I have already hinted, that two additional assistants at the very least would be required, and that the salaries of those I at present have should be increased, say to double. Doubling their salaries would make 200*l.* additional, which, together with two new assistants each at 100*l.*, would make 400*l.*; and besides that the mere doubling of the sum for my class expenses would be the very least I could ask; so that, in all, 525*l.* per annum additional would be the very lowest possible estimate, independent altogether of the salary of the professor himself. I need not mention that much larger sums of money could be not only employed, but employed with real advantage to the country as well as to the University.

9444. (*Professor Smith.*) Do I understand that the sum of 125*l.* which you mentioned is to cover the laboratory expenses as well as the class expenses?—Every expense connected with my teaching in the University.

9445. Then, although you have spoken of the efforts which you make to keep your stock of apparatus up to the level of the requirements of science in the present day, you must find the greatest difficulty in doing so?—I am obliged to limit my selection of apparatus to those new ones which are absolutely indispensable. There are many most important forms of apparatus which I am utterly unable to purchase.

9446. What is the usual number of the students in your advanced class?—It rarely exceeds five or six. However, I consider that a class of that size is not much less important than the junior class with its far larger number, because it is excessively desirable that in all parts of the country there should be a higher standard of instruction; and when we get men who under great disadvantages wish to study in a Scottish University the highest portions of applied mathematics, I conceive that every facility ought to be given for their instruction.

9447. Do you find any difficulty from the want of sufficient mathematical training on the part of students in your elementary classes?—I find so much difficulty on that account, that with more and more experience in teaching the elements of my science, I have gradually as far as possible excluded from my lectures to my junior class everything but the very elements of mathematics. I find, however, that even with five lectures a week there are so many demands upon my time for various important parts of experimental physics, that after all there is no necessity except in one or two branches, which cannot be taught without it, to introduce elementary mathematics; so that practically the difficulty is becoming less and less every year in that way, simply because in endeavouring to give a general view of the whole subject and every important part of it I have not time to dilate upon particular branches. For dilating upon the particular branches of course mathematics would almost necessarily be required.

9448. With regard to the advanced class, do you find that the small number of students who attend it generally come to you sufficiently prepared?—I adapt the instruction I give to the amount of mathematical preparation which I find in them. In some years I have had students remarkably well prepared with their mathematics, and able to follow me into almost any applications of mathematics to physics. On other occasions the students who present themselves are not so well acquainted with mathematics; and in fact I have sometimes almost to begin with them, under the head of dynamics, the subject of the differential calculus. I do not, however, teach the differential calculus, but merely introduce so much of its results as is requisite to enable the students to follow my lecture.

9449. That must add, must it not, to the labour of the Professor of Natural Philosophy?—It does not exactly add to his labour, but it prevents his lectures from being so effective as they might otherwise be.

9450. I think you did not mention light as amongst the subjects in your advanced course?—No, I find that there is absolutely no time for it, though I should be quite prepared to include it were part of the work taken off my hands by an assistant. The present programme for the advanced class has been arranged so as to make it as useful as possible to students who are reading for honours in mathematics or for the diploma of engineering.

9451. Then you do think that it would be possible with proper assistance for one professor to teach the principles of natural philosophy in the way that you have described to us, and also to give the instruction that you would wish to see given to the advanced classes in all those branches of mathematical physics?—Yes, certainly.

9452. Do you not think it would be too much to ask of one man, even with the best assistance?—With proper assistance I think one man could do it. I do not say that it would be advisable to require it of one man, but I say that one man could do it. Whether

P. G. Tait, Esq.

16 Feb. 1872.

it would be best done by one man or not is another point altogether.

9453. Then, if it were possible, you would not be unwilling to consider the proposal of having two Chairs of Natural Philosophy, the duties being properly divided between them?—There would be very great difficulty about the division. The difficulty would be to preserve the unity of direction which it has at present, and it is quite possible that in consequence of such a division some important subjects might be omitted altogether.

9454. (*Professor Stokes.*) You state, I think, that about 10 students were able to work in the laboratory?—About 10 at a time; so that I have 10 generally during the winter, and other 10 during the summer months; therefore I instruct 20 in all in the course of the year. The numbers vary occasionally, owing chiefly, however, to the greater or less resources as to space at the time. If I find my class room too much employed I must take fewer laboratory pupils, and so on.

9455. Do you think that the laboratory work of students is a thing requiring the direct superintendence of the professor, or a thing that can be done by assistants working under him?—The superintendence can be carried on, of course, by assistants, but the general direction of the work of the laboratory ought certainly to be looked to by the professor. The assistants, after having received instruction themselves, can in general superintend the work; but where difficulties arise, as very frequently is the case in all experimental work, it is almost necessary that the professor should give his assistance.

9456. How many students do you think you would be able to superintend in the laboratory work, if you had under you the assistance of a number of young men who had just been students, men who took the thing up for a year or two for the sake of perfecting themselves?—That would depend upon the qualifications of the particular men whom I could obtain as assistants. No doubt if a reasonable remuneration were given those men, I could even from my own old pupils perfectly easily collect a staff of assistants who would be of the greatest use in such a way as you describe, and whom I could perhaps trust individually with the superintendence of say 10 students each. I am not prepared exactly to say the number 10, but something very like that.

9457. Do you contemplate such remuneration as would secure their services for a considerable number of years?—I should say that if there were sufficient remuneration given them to induce them to stay with me for six or eight years each, I should have the best of their services, and the occasional benefit of a change, because there is always a benefit in change when it is not too frequent. A man is apt to get into a routine style, and a new man may bring in a new and fresh idea and mode of working. I should say that the remuneration should be of such an amount that it would keep them comfortably with me for six or seven years, but not such as to make them all desirous to retain their posts for life. It might be a thing to be considered whether the chief assistant is not a man whose post should be made such as he would not willingly leave except for a very much higher one.

9458. Speaking with reference to the Scotch Universities, do you think that it would be an improvement or otherwise that a University should grant degrees, as a reward for passing a certain examination, to students who had never been themselves at a University, but who had studied elsewhere?—I say most distinctly that a University should give none but honorary degrees, except where it has itself undertaken the teaching of the man to whom the degree is granted. I conceive that the primary object of a University is not in any sense to give degrees, but to teach: and that a University which teaches fulfils its mission infinitely better and more usefully to the country than one which gives any amount of degrees.

9459. (*Chairman.*) Are you aware of the intended career of your students?—In many cases I am, but I conceive that I have no right to inquire; it is only by chance that I become acquainted with their probable career. Many of them are intended for the ministry in the various Presbyterian churches of Scotland, and a great many of my best students are those who intend to devote themselves to the church.

9460. Are not the divinity students in the Church of Scotland bound to attend a course of natural philosophy?—I believe it is the case that theological students of all the Presbyterian bodies in Scotland are obliged to show that they have attended one series of lectures on natural philosophy.

9461. Have you many who intend to follow the medical profession?—A few. There is no provision in the University regulations for attendance on natural philosophy by medical students. They are required, I believe by direction of the Medical Council, to pass an exceedingly slight entrance examination in the merest elements of what is commonly called mechanics, and there is also another examination, a sort of higher examination, on what is called natural philosophy; but it would be absurd to say that the so-called elements of natural philosophy in which they are examined embrace the whole subject. I look upon the word "elements," when properly employed, as being of far higher signification.

9462. Are there any other points which have not been elicited in the course of your evidence on which you would like to express an opinion to the Commission?—There are a great many points upon which I could give information to the Commission, but I presume that unless they are directly connected with the teaching of natural philosophy, perhaps it might be more advantageously obtained from other witnesses better qualified than myself; but if the Commission have anything to ask me I will do my best to inform them. [*See* APPENDIX V.]

The witness withdrew.

A. Geikie, Esq., F.R.S.

ARCHIBALD GEIKIE, Esq., F.R.S., examined.

9463. (*Chairman.*) You are Professor of Geology and Mineralogy in the University of Edinburgh, and Director of the Geological Survey of Scotland?—I am.

9464. Will you be good enough to state to the Commission the circumstances which led to the foundation of a Chair of Geology and Mineralogy in Edinburgh? Up to the beginning of last year, geology and mineralogy had formed part of the natural history studies taught by the Professor of Natural History. It had been for many years found, that the scope of the subjects required in that Chair was much too great to be overtaken by one man, and several attempts had been made to subdivide the Chair into two, leaving the science of natural history or zoology, properly so called, in the hands of one, and geology and mineralogy in the hands of another professor. This was accomplished only last spring through a grant of 6,000*l.* to the University by Sir Roderick Murchison, and a supplementary grant from Parliament of 200*l.* per annum.

9465. And the interest of that 6,000*l.*, together with 200*l.* per annum, constitutes the endowment of the Chair?—Yes, the endowment of the Chair is 400*l.* a year, with 40*l.* for class expenses.

9466. Do you find sufficient accommodation at present in the University of Edinburgh for the requirements of the class?—The accommodation is quite insufficient. The accommodation consists at present of the use of a lecture room which is also used by two other professors. The room itself is very inadequate for the purposes of a lecture room for such a subject as geology and mineralogy, and, moreover, it cannot be obtained until half an hour before the time of lecturing; it is used previously by Professor Sanders, the Professor of Pathology, whose diagrams and specimens require

A. Geikie, Esq., F.R.S.

16 Feb. 1872.

to be removed before I can get in. There is only one hour during which these specimens can be removed and mine brought in, and my diagrams hung up. That is the most suitable class room which is at present available for the purposes of the Chair which I profess.

9467. Have you sufficient accommodation in that room for the exhibition of specimens ?—By no means: the lecture room is not adapted for the purposes of a natural history lectureship. Diagrams and models cannot be properly made use of, and the only table space for the exhibition of specimens is the desk which is used by the Professor of Moral Philosophy.

9468. What accommodation have you for keeping specimens required immediately in the lectures, and diagrams, and apparatus, and such like ?—There is no accommodation whatever at the lecture room itself. Within the last few weeks I have succeeded in getting a cellar in the south-east part of the College buildings, but that, from deficiency of light, distance from the lecture room, and difficulty of access, is not adapted for more than merely the purposes of a store room.

9469. Is it your desire to have the command of a distinct class room of your own ?—Most decidedly. The present accommodation, both the class room and the retiring room, and this cellar for the storing of specimens, is quite inadequate to allow the duties of my Chair to be performed as they ought to be. In order to the effectual performance of the duties of this Chair, I consider it essential first of all that the professor should have a separate class room, with a suitable lecture table and wall space, as well as the other accommodation which is usual for illustration of lectures by means of diagrams, models, specimens, and apparatus. In the second place, there is required a retiring room attached to the class room, with sufficient space for cabinets of specimens, diagrams, &c., and with proper light to admit of the examination of the specimens, and also with adequate provision of microscopes, lathes, blowpipe, and other testing apparatus for thorough practical instruction in the subjects of the Chair; for I consider that the duties of this Chair should consist not merely in lecturing, which is all that they can consist of at present, but in practical instruction by examination of specimens, and in the mineralogical part of the Chair by a series of carefully directed lessons in mineralogical research, and especially in research with the blowpipe and with the microscope. At present no provision exists for that practical department.

9470. You contemplate a systematic class as at present, and also a practical class ?—Yes, there should be a practical class in which the students would be made familiar with the characters of the specimens described in the lecture room, and would acquire thorough practical acquaintance with geological and mineralogical methods of research. This would be of immense service in relation to the education of engineers, miners, architects, and others.

9471. What specimens are at present at your command for the illustration of your lectures ?—In the College buildings themselves we have no specimens available for that purpose; but there exists attached to the College, and now the property of the Crown, a museum called the Edinburgh Museum of Science and Art, in which are placed the natural history collections which at one time were the property of the University, and which were handed over by the University to the Crown, with some agreement as to the use which the University might have of the specimens for lecturing and other purposes.

9472. What inducement had the University to hand over that property to the Crown ?—I never could quite make out.

9473. Was it that the Crown was to undertake the maintenance of them ?—The Crown was to undertake the maintenance of the museum, its enlargement and its increase; but I have always regarded the handing over of the University collections as a mistake.

9474. Confining yourself to what refers to your own department, you do not think that that was an advantageous arrangement ?—I think not.

9475. In what respect is it disadvantageous ?—It is disadvantageous in so far as the Professor of Natural History, although officially Regius Keeper of the museum, has not complete command and control over these specimens.

9476. Who directs the classification and arrangement of them ?—I believe the director or superintendent of the museum. That is Mr. Archer, an officer in the Department of Science and Art.

9477. He is not a professor in the University, I believe ?—No.

9478. When you require specimens for the purpose of your lectures, how do you proceed to obtain them ?—These specimens are obtained on a written application to the present superintendent of the museum. I may remark that I have no fault to find with the courtesy of the present superintendent. He is quite willing that the specimens should be lent, and has given me every facility and even personal assistance. It appears to me, however, matter for regret that the specimens are entirely beyond the control of the person who teaches geology and mineralogy in the University.

9479. In short, you think that he should have more immediate and direct control over them ?—Yes; the specimens may be removed, arranged, or added to without any communication whatever with the Professor of Geology and Mineralogy in the University.

9480. When it is deemed advisable to purchase additions to the collection, is the Professor of Geology and Mineralogy consulted ?—I have never been consulted, but the Chair has been so recently instituted that I am not quite prepared to say whether that might be done in future.

9481. What would you recommend as an improvement upon the present system ?—As far as I can see, the only way of adequately carrying out the purposes for which the museum was founded, and also the purposes for which the University collections were made, is, that the Professor of Natural History, who is also Regius Keeper of the Natural History Department of the Museum, should have complete command and control over every part of that department.

9482. That being in a distinct compartment of the great building ?—It is at present a distinct compartment of the great building. At present, officially, but not practically, he has this control, at least he is Regius Keeper of the museum. I think that although the general custody of the contents of the museum might be left with the superintendent, all questions as to the arrangement of the natural history collections, the purchase of new specimens, the disposal of duplicates, or the rejection of what is deemed worthless, should remain with the Professor of Natural History. In so far as these questions relate to the geological and mineralogical collections they might be referred to the Professor of Geology and Mineralogy, but without interfering with the supreme control to be exercised by the Professor of Natural History as Regius Keeper.

9483. As Director of the Geological Survey of Scotland, you can inform the Commission, can you not, as to any collections of specimens obtained through the Survey, and how they are disposed of ?—I am anxious that the Commission should be made aware of the fact that this museum of which I have spoken was first called the Industrial Museum of Scotland, and was founded by Parliament originally with the view of illustrating the industrial resources of Scotland. That view has been only partially carried out. The Geological Survey has been prosecuted for about 16 years in Scotland, and every year during that time considerable collections have been made to illustrate the rocks, fossils, and minerals of the various districts which have been under examination by the Survey. These collections have been to a very small extent exhibited in this museum attached to the University; a large portion of them, all or nearly all the fossils, and a large mass of rock specimens and minerals, which would be of great value to the public if they were exhibited, to illustrate wide areas of the country, are at present stowed away in cellars for want of any space in which to exhibit them.

A. Geikie, Esq., F.R.S.

16 Feb. 1872.

9484. Is there an actual want of space in the museum to accommodate them, or is there any indisposition to display them?—At present there is no space into which they could be put; the spaces are filled up, although it is a matter of opinion whether they could not be filled up more advantageously by the display of these specimens than by some others which are there.

9485. Is it in contemplation to continue extending the buildings of the Industrial Museum?—The Industrial Museum at present is undergoing great additions; several large halls are now in the course of construction.

9486. Do you consider that part of that extension might be appropriated very advantageously to receive the specimens derived from the Geological Survey of Scotland?—I think so. I think that one hall might well be devoted specially to the illustration of the geology of Scotland, not merely scientific but industrial, and that as a nucleus for that illustration the collections that have been made by the Geological Survey might well be made use of. At present they lie unknown to anyone in the cellars under the museum or in the office of the Survey.

9487. What is done with the superfluous specimens that are obtained in the Geological Survey; are they supplied to any collections throughout the country?—We do not collect superfluous specimens. At one time we collected duplicate specimens of rocks, one set of which went to Jermyn Street, and one set remained in Edinburgh; but the spaces in Jermyn Street are filled up, and we found that it was better not to collect specimens which could not be made use of.

9488. Supposing that the museums in different towns in Scotland were willing to receive specimens of that kind, would the Survey be able without any considerable expense or labour to supply them?—At present to some extent it could; but the appointment of one or two additional collectors would not involve much expense, and that would enable the Survey to distribute those specimens; the expense would simply be in the collecting.

9489. Even the Professor of Natural History, although he is Regius Keeper of the museum, has no control, has he, over the natural history collection?—The amount of control which he has over the collection would, perhaps, be better specifically told by himself.

9490. How is the collection of specimens derived from the English Geological Survey directed, that is to say, who directs the arrangement and exhibition of those specimens?—The exhibition of the rock specimens collected by the Survey is arranged by the Director of the Survey, Professor Ramsay, and the exhibition of the fossils is superintended by the Palæontologist to the Survey, namely, Professor Huxley.

9491. Besides the actual specimens of rocks and minerals a good many more appliances are required, are they not, for the proper teaching of geology and the illustration of it?—A great many more. I have referred already to the necessity for a practical class, and that practical class requires not merely the ordinary specimens and diagrams, it requires also models and apparatus of different kinds for the practical illustration of mineralogy, petrography, mining, &c.

9492. What number have attended your class, this being the first year that you have lectured?—Yes; I began to lecture in November; the class is not a compulsory one, and this is only the first session, but my numbers have reached 43.

9493. Are you aware what class of students they were, whether they were destined for any particular profession or not?—Some of them are mining engineers. Several of them are lawyers or in lawyers' offices. A number of them are country gentlemen who come to Edinburgh for the winter, and have no special occupation, but the majority of them appear to be students attending the other classes in the University who have a taste for geological pursuits.

9494. Are there any considerable proportion of them medical students?—I do not know what proportion. I know that a number of them are medical students.

9495. Is attendance upon your class a necessary part of the curriculum for a degree in Edinburgh?—It is not necessary for any degree.

9496. Attendance on the zoological course is necessary for the medical degree, is it not?—Yes. Attendance upon my course qualifies for the degree of doctor in science. After taking the other required subjects a man may obtain his degree through his proficiency in geology.

9497. (*Professor Smith.*) You have stated that the accommodation in respect of space at your disposal is extremely insufficient; we should be glad to know if you think that it would be possible to obtain in the buildings of the University the additional accommodation that you require?—Quite impossible so long as the University is not extended. There is no other class room more available for me than the one I have.

9498. So that you suppose that apart from some general plan for extending the University buildings it would not really be possible to find rooms for you?—I give my evidence merely to show the necessity for some such general plan, and to show how it affects my own department.

9499. (*Chairman.*) Is there any other point upon which you would desire to give evidence before the Commission?—None, except just in so far as to bear my own evidence regarding the necessity for further extension of the University buildings in Edinburgh. My own department has been recently founded, and of course there was no previous provision for the adequate teaching of geology and mineralogy; but as far as my department is concerned it is quite impossible that it can be at all efficiently taught unless there is additional space provided for it, and not only space, but all the apparatus and the other teaching appliances that I have referred to.

9500. It has been stated to the Commission that it is in contemplation to obtain a piece of ground in the vicinity of the present University buildings, and to transfer to it certain departments, the anatomical and chemical departments especially; would that give great relief to the existing building?—Great relief, indeed; it would relieve my own department of pressure, and would, I believe, provide quite sufficient space.

9501. Would it enable you to get all that you want?—I think so; of course it would merely give me space.

9502. With regard to the natural history students in Edinburgh, do any of them undertake the duty of teaching in other institutions or establishments eventually?—Yes, they do. There is one point further which I should like to speak of, and that is the great advantage which Edinburgh enjoys in the way of the development of the studies of geology and mineralogy, and, therefore, the desirability of having that department properly dealt with. I refer especially to the way in which the practical part of geology can be taught by the numerous natural sections which abound in the vicinity. I may remark that I have been able during this first session to take my class out on numerous excursions; almost the whole of the class come out with me, and they learn in a short while, and in a practical way, all the details of geological work, which they could not learn so well in a lecture room, and many of which they could hardly learn in a lecture room at all. I know of no part of the country where geology and mineralogy could be more efficiently taught, if we had, in addition to the abundant opportunities which we have in nature outside, a sufficient amount of accommodation and all the other appliances indoors.

9503. Supposing that accommodation and those

A. Geikie, Esq., F.R.S.

16 Feb. 1872.

advantages and facilities were provided, do you think that you could advantageously undertake to instruct the teachers of elementary and secondary schools throughout the country in geology and mineralogy, so as to give them a solid and practical acquaintance with it?—By attending my class and excursions, I believe that they would acquire that solid and practical acquaintance. [*See* APPENDIX V.]

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 23rd February 1872.

PRESENT:

SIR JAMES KAY-SHUTTLEWORTH, BART., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
BERNHARD SAMUELSON, ESQ., M.P.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

WILLIAM JOHN MACQUORN RANKINE, Esq., LL.D., F.R.S., examined.

W. J. M. Rankine, Esq.

23 Feb. 1872.

9504. (*Chairman.*) I believe that you are Professor of Civil Engineering in the University of Glasgow?—I am. Professor of Civil Engineering and Mechanics is the complete title.

9505. For how many years have you held that chair?—16 years.

9506. You are prepared to give the Commission some information on the system of instruction in mechanical and engineering science in the University of Glasgow?—Yes. The statements which I make will refer to the last 10 years, or about 10 years. Previous to that time there was, properly speaking, no system. There was a professorship of Civil Engineering and Mechanics, and the Professor delivered a course of about 100 lectures, but the students came without any special preparation, and followed no general course of study in connexion with that special department, and their qualifications were not tested in any way when they went away. About 10 years ago, we instituted a department of study in engineering science, as we called it, consisting of a course of study in the various branches of science that are applicable to engineering, and followed by a system of examinations, and the granting of what we call a certificate of proficiency in engineering science. We had a reason for giving it that title of engineering science; because we do not profess to teach pure practice, but the art of applying scientific principles to practice; and we did not want our certificate to pass as a certificate that the holder of it was fit to practise the profession, but only as a certificate that he possessed the requisite scientific knowledge. As to the details of the course of study, there is, in the first place, mathematics, which the student studies for one or two years, according to what his previous preparation seems to render necessary. If he has not passed through a preliminary examination, he has to study mathematics for two years at least. There is a preliminary examination by the passing of which the minimum time which he has to devote to mathematics is reduced to one year. When I say a year, I mean the University session for one year. Secondly, in natural philosophy or physics, if he studies for the minimum period of one session, it may be increased to two, according to the proficiency which he shows. Thirdly, as to inorganic chemistry, he studies until he has attained a knowledge of the fundamental principles of chemistry; of the chemistry of the more ordinary metals used in engineering structures and machines, such as iron, zinc, tin, copper, and so on; of the chemistry of building materials, such, for example, as cementing materials and building stones; and of the chemistry of air and water, and such elementary matters as that. The fourth subject is geology, and in geology his studies are specially directed to what the writers of the present day call lithology, a branch of geology that relates to stone and the substances that are used as building materials; he also studies petrology and stratigraphy, which have a bearing upon the execution of earthwork. Those are the parts of geology which are more especially applicable to engineering. Then the fifth branch of this department of study, which concludes the list of the compulsory branches, is civil engineering and mechanics, which is studied for two sessions. This branch relates to the art of applying the principles of the other branches of science mentioned to practical purposes. There is a special mode of treating such principles where they are to be applied practically—for instance, to engineering field work, to engineering structures, and to machines: a special method different from a purely scientific treatment. I will mention one of the special characters of the application of scientific principles to practice. For any given practical purpose there is a certain degree of precision required inferior to the precision required for purely scientific purposes; and the student ought to be able to judge of the degree of precision that is wanted in applying science to a particular practical purpose, in order that time and labour and expense may not be wasted on an unnecessary degree of precision. It is a very important and rather difficult subject. and I could exemplify it at great length, but I suppose it is not necessary to occupy the time of the Commission by giving detailed examples of it. Then, on passing a satisfactory examination in those five branches, a student receives a certificate of proficiency in engineering science. Further, if the student wishes to get a degree in engineering science, which is superior to a certificate, namely the degree of Bachelor of Science in the Department of Engineering, he must study any two additional subjects that he pleases, taken from the curriculum in arts. Further, he may get a degree with honours; the subjects to be studied for honours are prescribed. I am sorry that I have not with me a copy of the regulations upon that point, and I cannot remember the whole list of subjects for honours, but I remember some of them; such as the higher geodesy, and the more difficult of the mathematical principles of naval architecture. I may state that the ordinary course of civil engineering and mechanics includes the elementary part of the mathematical principles of naval architecture, but honours may be obtained by the study of the higher departments of the theory of naval architecture. Those are some, at all events, of the subjects for honours. The mode in which the instruction is given is, in the first place, by lectures, illustrated by experiments where the subject admits of it. Instruction is also given by setting written exercises to the students, which they answer in writing, and by holding frequent oral examinations, which are not so much to test the qualifications of the students for a certificate as to see that the students are all following the professor in what he teaches. This may be considered as part of the course of instruction rather than of the examination proper. In experimental physics, chemistry, and geology there are processes of instruc-

W. J. M. Rankine, Esq.

23 Feb. 1872.

tion which my colleagues either have explained or will explain. I understand that my colleague, Sir William Thomson, has already been examined, and will have given full details as to the instruction in physics. My colleague, the Professor of Geology, will be examined, and can give the details of the special method followed by him in that branch. All I need say is, that in experimental physics and in chemistry the students have not only experiments shown to them, but are made to work at experiments themselves; and in geology they are to a great extent taken over the ground and study geology on the spot. I think that that is a sufficient outline of the system of instruction in mechanical and engineering science in the University of Glasgow. Perhaps, I might mention what I have ascertained respecting the number and age of the students at present in that department. The average number may be taken at about 40: it ranges between say 34 or 35 and 50, or thereabouts, and their average age during the present year is 20.

9507. Would you inform the Commission in what state of preparation the new students who enter this department are found?—As far as I can judge they come, generally speaking, in a good state of preparation as regards mathematics. It is evident that those who mean to enter this department have most of them been well instructed in the elementary parts of mathematics, either at schools or by private teachers. I know it to be the practice of a good many of them to prepare themselves by the help of mathematical tutors. As regards mathematics, I think, on the whole, the state of preparation is good. In former years it used to be very imperfect—especially previous to the institution of the system which I have described—it used to be very imperfect, but now it is good. I find that I made an omission, in stating the course of study and examination, in answering a previous question. I ought to have said that before granting a certificate of proficiency, the Board of Examiners judge of the proficiency of the candidate in drawing. We have no provision for, and no means of teaching drawing in the University; it has to be learnt outside, but we make the students produce drawings, and we judge whether they have an adequate knowledge, more especially of mechanical and engineering drawing. I may say that that is a point upon which they come least well prepared—there is evidently a deficiency of good instruction in drawing. The best of them, those who at once without any delay produce drawings to satisfy us, have almost all come from the drawing office of some work, some mechanical engineering shop, or from the office of some civil engineer, and, therefore, have had to make working drawings previously for practical purposes; but as to those who come who merely learn drawing in schools from teachers, some of those are good no doubt, but they are less well prepared decidedly than they are in other things, and that makes me believe that there is a want of sufficient instruction of a proper kind in drawing throughout the country generally.

9508. As to the state of preparation in other respects, are they tested by any entrance examination?—As to testing their preparation, there is no compulsory entrance examination at all, but there is a voluntary entrance examination, which I mentioned before. The mathematical part of that voluntary examination is the only one that I need mention. It is a preliminary examination instituted originally in connexion with the study of arts. If a student passes that examination in a satisfactory way, the duration of his attendance, if he is a candidate for a degree in arts, in shortened by about a year. In engineering science it is the mathematical branch of that preliminary examination that is operative. If candidates choose, they can undergo that, and if they pass it the duration of their mathematical studies at the University is shortened. We have no compulsory test on entrance, and that is the only voluntary preliminary test. I have been asked a question about their preparation in other subjects than mathematics and drawing. I think that preparatory study is scarcely wanted in the remaining subjects; it might possibly be of service in chemistry, and, perhaps, in elementary statics and dynamics, but that I would rather leave to some of my colleagues to speak to. In the remaining subjects, it can hardly be said that a preliminary study tested by examination is necessary. Mathematics is really the foundation of the whole subject, and that is the branch of science in which preparation previous to entering our University is specially desirable.

9509. Is there anything which you would desire to state to the Commission as to the results of experience in the modes of conducting the instruction in this department?—Yes, I would describe the mode of conducting the instruction as the result of experience, but as to special matters the main point which has been impressed upon me by my experience is the advisability of carrying on scientific study and practical study, as completely separate and independent departments. When I first became professor the lectures were attended to a considerable extent, and to some extent they are attended now by young men who are actually engaged in business at the time, and who are working at some practical business as civil engineers or as mechanical engineers during one part of the day, and get leave of absence, or find leisure, somehow or another, to attend the lectures also. From my experience that does not answer. It is too great a strain for one thing upon the mental faculties; and then the states of mind required in practical operations and in scientific study are so different that a sudden change from the one state of mind to the other at different periods of the day is injurious to both. In the earliest years of my holding this professorship I was induced to give evening lectures. In fact, my predecessor lectured in the evening and I followed the same plan, in order that not only young civil engineers' assistants, but young men engaged in mechanical engineering works and in workshops might be able to attend, but I found those evening lectures were all but useless. The students were very attentive, they all came voluntarily and through pure zeal for acquiring knowledge, because they were to get no special advantages from it; at that time there were no certificates and no degrees; as I say, they were most attentive and orderly in their behaviour, but when I came to examine them I found that the instruction given to them had taken little hold upon their minds. I found, in fact, that from the state of bodily and mental fatigue in which they were, although they might be quiet and attentive and listen with interest, there was little or no permanent benefit gained. and after giving those late lectures a fair trial, I adopted the system of lecturing just at such an hour in the afternoon as was most convenient in connexion with other classes in the University, an hour which was vacant as regarded other branches of study, namely from 4 to 5.

9510. Have you any suggestion to make as to the bearing of those results on the general subject of technical education?—As regards the general subject of technical education my experience, which I have already mentioned, leads me to think that the delivery of lectures in the evening, for instance, or at short intervals between working hours, to men who are actually engaged in work, will not give them that sort of knowledge which will be practically useful to them. It may have a general improving effect upon their minds, and it may be a good way of passing leisure time; but I do not expect from it the proper results of scientific instruction, or instruction in the application of science to practice. I believe that in all matters of technical education it is best to find means to have the periods of instruction not on the same day, but at separate times of the year, if possible, from the periods of work. There is another remark which I may make with respect to technical education which bears upon the state of preparation of our students. I think it is of the very greatest importance that technical education, and elementary education with a view to technical education, should embrace the subject of drawing. I

W. J. M. Rankine, Esq.

23 Feb. 1872.

think that even primary education should embrace some little drawing, and freehand drawing is the best for that purpose; but when you come to technical education with a view to any mechanical pursuit, a knowledge of the elementary principles of the art of mechanical drawing is of extreme importance.

9511. Have you any recommendation to make as to the best way of combining practical with scientific instruction?—It results very much from what I have already been saying, that the best way to combine practical and scientific instruction is what we actually practise, indeed, to a great extent, or induce our students to practise as far as we can, that is, to devote the winter half of the year to scientific study, and the summer half to practical work. There was a little difficulty at first, but now we find that there is not much difficulty in inducing the mechanical engineers and shipbuilders and the like in our neighbourhood to take pupil apprentices, on the condition that they are to attend to work during the summer half of the year, and attend on the University during the winter half, giving their whole attention to work during the one period and to science during the other. There is a further remark which I would make on the combination of practical with scientific instruction. I think it useless to attempt to give instruction in practice proper in a University. If, for instance, we set up a mechanical workshop with machine tools in it in our University, or if we got, say, a mile or two of railway, and set our students to superintend the works, this would be worse than useless. The difference between doing things on a small scale like that, and doing things on a great scale, as in actual practice, is so great that the students would only be led to fancy that they had more knowledge than they really did possess, and, therefore, I am for having the practical knowledge acquired at separate times and places by practice on a great scale. There is one rather apparent than real exception to that. I think that a certain degree of instruction in mechanical manipulation would be useful in our University, or in any University indeed, but rather in connexion with experimental physics than with engineering: such instruction as would make a student, if he were engaged in scientific inquiry, able to make his own apparatus. That actually goes on in the University of Glasgow in the physical laboratory. A great deal of the apparatus used there is made by the students themselves, under the superintendence of the professor and his assistants. This would be useful to young engineers as well as to other students; but they should not be led to suppose that in practising mechanical manipulation on that scale they are at all qualifying themselves for the practice on the great scale that one meets with in engineering workshops, or in the execution of lines of railway or other engineering works.

9512. What do you consider to be the proper functions of a University in the education of engineers?—What I shall say in answer to that is very much a recapitulation of the main points which I have already submitted to the Commission. The proper functions are, first, to teach those branches of science proper that are applicable to engineering and mechanics, and, secondly, to teach the special art of applying scientific principles to practical purposes. I referred to that in my answer to the first question, and I referred in particular to a knowledge of the degree of precision necessary in making such applications. The University having given the student this instruction, and having examined him to see that he is properly proficient in it, can then certify that he is a proficient in engineering science, but not that he is one qualified to execute or to superintend works. I think there is a limit to the function of a University, which is to impart and to certify the scientific knowledge, but not to certify the practical skill, of the candidate.

9513. Has the University any wants with respect to the efficiency of the department of mechanical and engineering science which you think ought to be supplied?—It has wants, and they of course, like all other wants, resolve themselves into the want of money; but as to the purposes for which additional money would be required they are of this kind. It would be an advantage if we had an additional endowment sufficient to supply, for one thing, instruction in drawing, of which I have spoken as being of great importance in the University. In connexion with the teaching of the scientific principles of naval architecture, which I have mentioned as one of the subjects of my lectures, there should be an assistant, a lecturer, or a teacher of some kind, to teach a variety of details that are not properly the subject of lectures, but such details as are taught in the Royal School of Naval Architecture, namely, the preparation of the plans of a ship and the making of a set of routine calculations which in designing a ship are always required. This in fact can only be done by the help of some assistant or teacher for that purpose. It might be desirable to have a special teacher for mechanical manipulation, but, as I said before, the Professor of Natural Philosophy, perhaps, is the best judge in that matter, and such a teacher would probably be better attached to his class. There is also a want of a fund for providing a collection of specimens of materials. We ought to have a complete collection of specimens of iron, wrought and cast, of various different kinds, to teach students to judge of their appearances, and specimens of various sorts of timber that are required in engineering construction, of the various kinds of building stones, and of the various kinds of cementing materials. We have a few things of that description collected casually, but we at present have no means of making so complete a collection as we ought to have.

9514. (*Dr. Sharpey.*) Have you space?—Yes; we have in fact some pretty large rooms which were intended for that purpose in designing the new University buildings. There was not space in the old buildings. I believe if there had been, we might, perhaps, have had a larger collection through voluntary contributions. In the new University buildings we have rooms intended for that purpose, but they are nearly empty, and although, from private liberality, we have got a few specimens of materials, yet they do not form a collection, properly speaking; there is no system in them; there are gaps in the collection, and we cannot expect individuals to send just the thing we want. We get large quantities of wooden models of ships, which are very useful, and we get some specimens of different qualities of iron, but we do not get a complete series, which is the important thing, and we get duplicates which we do not want. In various ways the collection is very defective, and we have no funds of our own to provide a proper collection.

9515. (*Chairman.*) With regard to the promotion of original research in science, are there any considerations which you would like to present to the Commission?—Yes; it is a very distinct subject from that of instruction in science. But I would say this, in the first place, as to the money required for original research in science, if it is to be provided by the Government, that it appears to me that there can be no general principle laid down as to the granting of money from the funds of the State for original research in science, and that every proposal for any such grant ought to be considered separately on its own merits. The necessity for such grants arises when there is some subject of research involving experiments or observations, or other matters of expense beyond the means, either of individuals or of societies, and under such circumstances the Government may reasonably be applied to. But as to what applications should be granted, and what should not, I think there is no general principle, but every case must be judged of on its own merits. The other thing which is wanted, besides money, is the leisure time of competent persons. It seems to me that it is out of the question for any State to provide or endow such a set of persons, and that it would be impossible for any department of the Government, either to judge who were fit persons, or how they ought to be employed, or what would be a

W. J. M. Rankine, Esq.

23 Feb. 1872.

proper remuneration for them. And I believe that if any such system were instituted, it would only lead to abuse. Setting aside such leisure time as men may have who are of independent fortune, and do not require to practise any profession or special occupation, I would say that it appears to me that in order to ensure that other competent persons shall have the requisite leisure, it is desirable that there should be offices with other functions attached to them, but those functions should be of such a nature that the holder of the office may have leisure time for original research. It seems to me that the Universities, as they now exist, provide a good deal of what is wanted in that respect—that such offices as fellowships and professorships, and even scholarships, afford a means of maintenance to persons competent for original scientific research, and at the same time leave them an amount of leisure, at certain periods, which enables them to pursue it. I believe that the proportion of leisure time is pretty much the same in the Scottish as in the English and Irish Universities, although differently distributed. The Scottish Universities have a winter session of six months, during which most of the studies are carried on, especially those connected with arts, and they have an additional short session in the summer of three months, connected with the medical faculty, and with chemistry and the various branches of natural history. So that there is a vacation of six months in some departments, and of three in others. And it appears to me that that is not only beneficial, but necessary, for the purpose of affording time for original research in science, and a good deal of that is carried on, not merely by professors, but by students. In the English and Irish Universities there are fellowships, and it is to be desired, I think, that there were institutions like fellowships in the Scottish Universities also.

9516. (*Sir John Lubbock.*) Referring to what you have just now said with regard to the winter term in the Scottish Universities, does it afford practically an opportunity to men in a humble sphere of life to come up to any extent in order to pursue university studies in Scotland?—Yes, in the Department of Arts, and in fact in every faculty except that of medicine, the having of a single term of six months, and then six months' vacation, is peculiarly advantageous to students who are in poorer circumstances. It is an expense and an inconvenience to them to come up to the University oftener than once a year, and it would be a very considerable obstacle in their way if there were a division of the session into two or three terms, involving their coming up two or three times a year.

9517. I presume that the being able to come up for half a year and then to return to their ordinary avocations for the other half-year, is in itself a very great advantage?—Yes, it is a very considerable advantage.

9518. Particularly as there are so many occupations which can be followed in summer and which can hardly be carried out with advantage in winter?—Yes; but with respect to this question it bears very much on a class of students that I do not know much about of my own knowledge—students in arts, for instance, and students in divinity, and the like. As to students in the engineering department, that being a matter which I know from my own personal observation, the advantage to them of the six months' vacation is what I have already mentioned, as enabling them to go to some work for a period of six months without interruption.

9519. Could you give the Commission any information as to the extent to which the Scottish Universities are availed of by persons in a comparatively humble sphere of life?—No, I cannot. That does not fall within my knowledge. I may state that I rather think that the extent to which that goes is a little exaggerated in the ordinary conception. It is quite true that they are made use of by many young men in a humble sphere of life, but it is not the case that the majority of the students are in poor circumstances, as I think some people believe.

9520. Still the arrangement is, I presume, in your opinion, of considerable importance?—It is very important.

9521. Do you think that anything could be done to introduce a similar system into our English Universities?—I do not know; I have not considered that matter.

9522. Do you see any special reasons to the contrary?—No; the fact is, that I do not see any reasons on one side or the other, for it is a subject which I have not considered.

9523. (*Mr. Samuelson.*) In treating of the subject of machine construction, do you consider it historically and descriptively?—As to historically, if you mean the history of inventions as regards machines, and the progress of improvement, I have not time to treat that at the length which I should wish to do. I usually introduce something about it when there is time, for instance, in an introductory lecture, but there really is not time to treat it at the length which I should wish to do; there is so much to be taught as regards the actual state of knowledge and its mode of application. Then as to descriptively, I do not quite see how you intend to limit that term. I describe machines of various sorts, but specially with a view to the bearing of scientific principles upon that description, and upon the mode of designing and constructing them.

9524. You present to the students the best examples, and you tell them, do you not, why you consider them to be the best?—Yes.

9525. Do you also bring before them instances of failures?—I do not bring before them special instances of failures, but I show them the causes of failure. I explain to them, in a general way, what sort of failures may occur, and what is the cause of them, and how they are to be avoided; but to mention a special structure on a special machine which did fail, and enter upon the causes of it, would be rather an invidious thing to do, and might involve reflections upon individuals.

9526. But if it were desirable for the sake of the student, would that be a reason for not entering upon it?—I can mention in a very definite way some sort of failure that I know of, but without saying where it occurred, or who is responsible for it, and that I do. I say, for instance, I saw a structure of such and such a kind (giving them the dimensions and everything about it) which failed in such and such a way, and it was from neglecting such and such a principle, but I do not say where it was, or who designed it. I do not specify it in that way.

9527. Before granting a certificate of proficiency, or a degree in engineering, do you always require proficiency in arts?—With regard to the meaning of the word "arts;" there is a conventional meaning in the University, namely, the subjects in which a student is examined who is a candidate for M.A. If that is what you refer to we do not require all the subjects for a degree in arts, but I may state that, for proficiency in engineering science, the examination in mathemathics and in natural philosophy is such as would qualify for second-class honours in arts; it is beyond the proficiency required for an ordinary degree in arts as M.A.

9528. My question is as to the University: do you require any subjects in arts to be brought up in order to qualify a student to obtain a certificate from you in engineering?—Yes, mathematics and natural philosophy.

9529. But no strictly literary subjects?—No literary subjects for a certificate; but if a student wishes to become a graduate, that is, practically to become a member of the University Council, and have a vote for the member of Parliament, we require that he shall be examined in two subjects in the curriculum of arts over and above those of mathematics and natural philosophy already specified, and those subjects, or at all events one of them, must be literary or philosophical.

9530. With reference to the evening classes you stated that the instruction appeared not to have taken hold on the minds of the students, and you attribute

W. J. M. Rankine, Esq.

23 Feb. 1872.

that in a great degree to their being engaged in manual labour during the day, might it not also be attributed, to a considerable extent, to the want of preparation on the part of the students?—The want of preparation would affect the way in which a lecture which I delivered at any time of the day would take hold of their minds, but what I specially refer to is what I could not doubt was the effect of being engaged not necessarily in manual labour, but in labour manual or mental during the rest of the day; for instance, in office work, surveying or drawing, or work in a machine shop, or any sort of work of that kind, and I may state one reason for being certain that that was the cause of the instruction not taking hold of their minds: that many of those very students were exceedingly well prepared, and had a very good previous knowledge of mathematics, and of some other branches of science, but more especially mathematics.

9531. Was that generally the case with regard to your evening students?—Yes, most decidedly.

9532. They were scarcely, I presume, what might be called working class students?—Some of them were, that is to say, they were working apprentices; they were not journeymen. If apprentices are properly managed in a workshop they are, to all intents and purposes, employed in the very same way with the journeymen, according to their ability.

9532*a*. You stated that the Scotch system of having a winter session and leaving the remainder of the year free for practical working was probably the best for combining practical and scientific instruction; in those cases in which that alteration cannot be adopted, do you think that there is any use in having workshops in the institution for theoretical instruction which shall enable the students at any rate to become acquainted by what I may call contact with the properties of materials?—I have mentioned the sort of workshop which I think would be useful, a mechanical workshop on a small scale, but more with a view to the making of physical instruments than of machinery proper, and I give the preference to that because although the workshop is on a small scale it really produces practical results; it produces things that are to be made use of.

9533–4. Are you acquainted with the workshop at King's College?—I have never seen it.

9535. Of course in the production of such appliances as you have described, the file and other tools would be used?—Yes.

9536. In itself you would think that to be desirable, would you not?—Yes, I think it would be desirable.

9537. The subsequent employment of the students would also determine, would it not, in some degree the relative amount of practical knowledge which it would be desirable for them to acquire?—The sort of practical knowledge rather. If a student means to be a mechanical engineer his six months' vacation had better be spent in a mechanical workshop. If he means to be what is called a civil engineer in the special sense of the word, he ought, if possible, to be upon the works of some railway, for instance, or some waterworks, or harbour works, or the like. As regards instruction in mechanical manipulation within the University, I think the kind of study and knowledge required by all students is pretty much alike. Every student, indeed, even those who are to be railway engineers, or to be engineers of harbours or waterworks, ought to understand the making of machinery.

9538. In fact they ought to have as much practical instruction therein as can only be obtained upon works?—Yes, I think that is most desirable.

9539. Are you able to say whether the number of students in the department of engineering has increased within the last few years?—Yes. Before we established a systematic course of instruction, when there was only an isolated course of lectures in engineering, the number used to be both very small and very fluctuating. The first year that I lectured I had about 20 students. When students came to me wishing to enter my class, I had no power to exclude them, but I used to advise them not to enter it without a certain amount of previous knowledge, especially of mathematics. The consequence of my giving that advice, and pressing it upon all students that came, was a gradual falling off in the numbers, and at length it came to pass that I had only some eight or ten. We then established a systematic course of study in the branches that I have enumerated, and then they began to increase, and they went on increasing, until, a year or two ago, the number reached, I think, the maximum of 47 or 48. Since that it has kept fluctuating, sometimes above 40 and sometimes below; but I believe 40 to be now the average, and that we shall see a small fluctuation above and below that average.

9540. How long ago is it since that special department was instituted?—The systematic course was instituted ten years ago.

9541. Then it has existed sufficiently long, has it not, to enable you to trace the careers of some of the men whom you have turned out?—Yes.

9542. Can you give the Commission any information upon that subject?—Yes. I think that on the whole they have succeeded very well in their after career. I cannot give anything like a complete account of the matter. I can only state examples that occur to me at this present moment. There is one who is chief engineer of the principal government dockyard in India. There is another who is chief engineer of the docks at Pernambuco in Brazil. There is another who has been lately appointed borough engineer of Liverpool, and I may say that next to the appointment of chief engineer to the Metropolitan Board of Works, that is the most important appointment of the kind that exists. Another is manager of one of the most important mechanical engineering works in London. Those are all that occur to me at this moment, but, so far as I know, the great majority have succeeded very well.

9543. You would say that upon the whole the appreciation of the kind of instruction which you give is on the increase?—Yes, decidedly.

9544. Would you say that it was increasing amongst the employers?—Yes. I may state that my predecessor was a very able and energetic man, Mr. Lewis Gordon. He resigned the appointment of professor, owing to the great increase of his ordinary engineering business; but during his time, as I well know, for I observed what went on, there was a decided prejudice, perhaps more on the part of the general public than on the part of employers, against scientific knowledge in any man engaged in any practical occupation. There seemed to be an idea that it drove his practical knowledge out of his head, and that the two things were inconsistent. And the same prejudice existed to some extent when I got the appointment. Indeed, when my predecessor resigned there was a considerable difference of opinion as to whether the chair ought to be kept up. It was decided that it should be kept up, and I think that the kind of prejudice which I have mentioned has gradually died out, and there is almost an end of it now.

9545. Do you find that many of the employers are sending their own relatives to attend your course?—Yes, they are; and there is one illustration of the views of the employers regarding it, that a great many of them are affording facilities for that special arrangement which I mentioned of six months' work and six months' study. It has not hitherto been a frequent arrangement, but now various employers of high standing are quite willing to agree to it.

9546. That is a recent change of opinion upon their part?—Yes, quite recent.

9547. You yourself consider it to be of very great value indeed?—Of the very highest value.

9548. From that I should conclude that if technical schools of a high class were established it would be desirable that the preference should be given to the localities in which there could be a combination of practical and scientific instruction?—On the whole there should be a preference given to such localities, but it is not absolutely necessary to choose such a

W. J. M. Rankine, Esq.

23 Feb. 1872.

locality, because with the sort of arrangement I have mentioned the pupil has only to move from the works to the college, or from the college to the works once a year. For example, in the Royal School of Naval Architecture they have only to come up to attend the school once a year, and then go away to some dockyard once a year. If there are to be more frequent alternations of study with work, then it becomes essential to have them carried on in the same locality, but that necessity is very much diminished by having a long period of study and a long period of work.

9549. Is it not the case that you would be more likely to interest the employers in granting facilities for this alternation, if their workshops were situated near the locality of the school?—To a certain extent I should say it is an advantage, for instance, that I know personally, and have ready access to, various employers in Glasgow and the neighbourhood; but there is no impossibility in having that same sort of influence with employers at a distance.

9550. But practically you find that even to the professors there is an advantage in having ready access to the workshops of large constructors?—Yes, there is decidedly an advantage in that.

9551. Is it the case also that employers are more likely to appreciate scientific instruction if they are placed in contact with those who devote themselves to it?—To a certain extent they are; but still I have known a great many employers quite at a distance from the place where the scientific instruction is carried on who have appreciated it. A number of my students come from very long distances, some from the south of England and some from foreign countries.

9552. Have you many students from European countries?—No, comparatively few; I should have said that many of them come from the colonies, and as to foreign countries they are mainly such countries as Brazil and other non-European foreign countries. I have had students from Japan, Ceylon, and different parts of India, and I have had students from Turkey.

9553. Have you had students from Russia?—No, not from Russia; I have had some very good students from Spain.

9554. (*Professor Stokes.*) I gather from the part of your evidence relating to the promotion of original research that you would be opposed to the creation of an establishment for continuous experimental investigation, that is to say, an establishment which should be for experiments what an observatory is for observation; am I right in that impression?—No, I am not opposed to an establishment of that sort where some sort of routine is to be carried out, but what I should object to would be the appointing and paying by Government of a class of men to direct original researches, or to originate some new field of research.

9555. (*Mr. Samuelson.*) You spoke, did you not, of the subjects of original research as being proper to be considered each on its own merits?—Yes, as to whether a sum of money should be granted by the Government, or any other facility, such as the loan of a ship, should be granted for the purpose of prosecuting some particular original research. I think each subject should be considered on its own merits.

9556. What would be the tribunal which should decide such points?—That I am at a loss to say. I have no distinct idea as to what the tribunal should be. Of course it will come to the House of Commons in the end, because it must be sanctioned by them; but what tribunal should have the function of proposing such things to the House of Commons I am not prepared to say.

9557. (*Dr. Sharpey.*) Do you think it should be a permanent tribunal established for the purpose, or that the Government might vary their advisers according to the circumstances?—I am afraid of abuses arising if there were a permanent tribunal. I am doubtful how it would work.

9558. (*Sir J. Lubbock.*) Do you think, for instance, that the Council of the British Association, or of the Royal Society, would be as good a body as could be selected for the purpose?—On the whole, I think if the Council of the British Association or the Council of the Royal Society were selected, there would be as little objection to those bodies as to anybody that can be thought of.

9559. (*Professor Stokes.*) Do you think that there is any branch of physics in which it would be desirable that what you call routine work should be gone through in the way of experiment as distinguished from observation?—I am not very well prepared to answer that question, but just at the moment it occurs to me that in chemistry and in the mechanical properties of materials, the strength and elasticity of materials, for instance, some sort of routine work might be carried on with advantage.

9560. And the investigation, for instance, of the properties of the great variety of alloys?—Yes, certainly. I think that there might be permanent institutions for such purposes as those, because there are always arising, not merely new materials, but new specimens of known materials, and there would be an advantage in having their properties, whether mechanical or chemical, tested by some independent permanent institution.

9561. (*Dr. Sharpey.*) In the case of institutions especially intended for teaching the applications of science which are not connected with any University or college, or institutions in which courses of study in general science are pursued, do you think it is advisable that in those special institutions they should provide instruction in general preliminary scientific knowledge for those who enter them, or should they leave it to the pupils to obtain that preliminary knowledge where they may, and test it by an entrance examination?—I am not prepared to give a decided opinion upon that. Both ways might work very well, but I cannot make up my mind which is the best.

9562. I mean partly with a view to economy?—With a view merely to economy possibly it might be better to let them get their preliminary general scientific instruction where they can, and test it by examination, but that is a purely economical view, and as to what would be the comparative working of the two systems in other respects I cannot give a positive answer.

9563. What I had in view was this, that in many of those cases the same general course of instruction would apply to all, and it might be obtained, therefore, in some place where it was given at any rate instead of establishing in each particular school a staff of professors and teachers for that purpose. I refer particularly now to the cases of the Jermyn Street School of Mining and Metallurgy, the School of Naval Architecture and Engineering, and the Indian School of Engineering which has been lately instituted, three institutions all maintained by the State, and the question is whether it is good economy for the State to establish a staff of professors for general instruction in each one of those schools, or whether it would not be better and equally effective to institute an examination to test the qualifications of the students before entering those institutions?—I am not prepared to give a decided opinion upon the question in that shape, because it involves a number of very complex considerations. It depends, for one thing, upon the number of students in each branch of science. In some cases it may be desirable to conjoin professorships, because if they are kept distinct each of them has too few students; in other cases it may be advisable to have separate professorships, because otherwise the number of students would become unmanageably numerous. I may state as regards my own particular class in my department of study that I do not think it desirable that there should be more than about 50 students, because I should not be able to give that amount of individual attention to each which I think desirable. At the same time, supposing there were say five professorships, each with only 10 students, I should say that it would be an advantage to join those five in one, but if there were one professorship with say 200

W. J. M. Rankine, Esq.

23 Feb. 1872.

students, I think that that class had better be split up amongst three or four.

9564. Supposing that in your class you had ever so many students, you would still expect that they would go through a course of study in general science in the University classes?—We do not make it obligatory. The condition which we lay down is this, that they shall have attended such and such classes in any chartered university in the United Kingdom, and shall undergo examination by us, and if they pass that examination we take them.

9565. That is exactly the case that I had in view, and I wanted to know whether the same thing might not be adopted in reference to those schools of applied science elsewhere?—It is not an answer to Dr. Sharpey's entire question, but it answers part of it if I say that on generally applicable branches of science, that is to say, branches of science that are applicable to a variety of different departments, I am quite favourable to the principle of admitting any student into the school who passes a proper examination, although he has studied the elementary branch somewhere else.

9566. You spoke of the advantage of the winter course of study for students in humble circumstances. In Glasgow they are a good deal aided, are they not, by bursaries?—They are in Glasgow, but not to the extent that we should wish. I understand from information elsewhere, that the University of Aberdeen is particularly well provided in that respect, and that that is found a great advantage for the poorer class of students. We have a great many bursaries in Glasgow, but they labour under the defect that a good many of them are presentation bursaries, where there is not an open competition amongst all candidates whatsoever. We have a good many bursaries freely open to competition, but what I should like to see would be to have the whole body of bursaries open to free competition, and then we should be very well provided in Glasgow with the proper sort of bursaries.

9567. (*Professor Stokes.*) Would you make any restriction as to the pecuniary circumstances of the parents of those who are candidates for bursaries?—No.

9568. (*Chairman.*) Is there anything that you would like to add to what you have already stated to the Commission, arising out of your examination or otherwise?—No; I think there is nothing that I could add. [*See* APPENDIX V.]

The witness withdrew.

JOHN YOUNG, Esq., M.D., examined.

J. Young, Esq., M.D.

9569. (*Chairman.*) I believe you are Professor of Natural History in the University of Glasgow?—Yes.

9570. For how many years have you held that Chair?—For six years.

9571. Have you any remark to make upon the adaptation of the Chairs of Natural History in Glasgow and Aberdeen to the work for which they were intended?—I have this to state, that as the Chair is at present arranged it is perfectly impossible for the holder of that Chair to do justice to the work that is expected of him; that in the first place he is required to teach zoology to medical students; in the second place he is required to teach geology to students of engineering; that those two offices are incompatible, since to discharge the one adequately he would require to spend his whole year in dissections and indoor study; and to do the work of the other he would require to be the major part of the year in the field making investigations in geology, and that the combination of the two duties renders it imperative upon the teacher to neglect, to some considerable extent, one or the other. In my own case I have been obliged to surrender the geological section of my work to some extent, so as to attend more thoroughly to the medical students, the requirements of the General Medical Council making it imperative upon me that I should do my best for the very large number of medical students who attend my class.

9572. What is the condition of the emoluments of those Chairs?—I have 200*l.* altogether from Government from a parliamentary grant. My fees amount to 260*l.* at the outside; at the present time I am lecturing to 15 students of engineering for three months at a remuneration of 46*l.* That is a sample of the bad distribution of the emoluments; and I have no residence. I have 100*l.* from the senate as Keeper of the Hunterian Museum, but that is an annual appointment, and it is one moreover which the senate may withdraw from me at any moment. It is a private trust, and when I was appointed the tradition of the old competition between the University and the Crown made it doubtful whether I should receive at the same time the appointment as keeper.

9573. It is not necessarily connected with the Chair?—No, it is not.

9574. I understand the emoluments which you have enumerated to be for the combined Chairs of Geology and Zoology?—My commission is Natural History without the slightest modification. It contains no suggestion as to a division of the subjects, and no restriction as to the number of lectures; in fact I am left perfectly free. I understand that I am in a position to defy the University if it chose to institute prohibitions upon my procedure, so uncertain is the present arrangement.

9575. The extent of your lectures is, therefore, a matter of goodwill, and the whole mode of treatment within your own discretion?—Yes. As regards medical students I must give 50 lectures; but as regards geology it is at my option to continue the old custom of mixing up geology and zoology, as was done many years ago, and as I believe is still done to some extent in Aberdeen. When I was first appointed to Glasgow, I thought it desirable to separate the two subjects, and the first summer that I held office I lectured two hours a day, one hour upon zoology and another hour upon geology. The following year I gave the geological lectures in spring and the zoological lectures in summer, and I have continued that since; but the very small number of students attending the class makes it a question with me whether I shall continue to do this, because by spreading the course over the six months in this way I am compelled to sacrifice a great deal more time than I might do if I combined the two, and were to limit my whole course of lectures to 50, as is in my option, or added a second lecture upon certain days of the week upon specially geological subjects. By so doing I might have a winter course on zoology.

9576. Have you sufficient assistance from demonstrators, and other subordinate agents, for your lectures?—But for the accident that I am Keeper of the Museum I should be absolutely without assistance. There is an assistant keeper of the Museum who receives a salary of 100*l.* a year from the University; and in my own interest I pay him 25*l.* a year out of my own pocket to secure his co-operation in the geological course. Other assistance I have none as regards the Chair. What assistance I have therefore comes entirely out of my own pocket, and no provision in the Universities' Act admits of my receiving such assistance, because the terms of the Act go to forbid an increase of the emoluments of any professor.

9577. Of what class do your students chiefly consist?—I have two classes; the medical students on the one hand and the students of engineering science on the other. I have scarcely any other auditors except members of those two classes. I have endeavoured to procure other auditors. My fee is three guineas, and I have intimated to the students of theology that I would receive them at one guinea, representation having been made to me as to the desirableness of theological students attending my course, but that has been practically inoperative. I have had only one divinity student applying under that offer.

J. Young, Esq., M.D.

23 Feb. 1872.

9578. What is the condition of the encouragements offered, and what are the regulations of the University as respects arts students?—As regards the arts students, there is at the present time, one may say, absolutely no inducement for them to attend. They have a very heavy examination in the three departments of the arts course, and the ordinances allow the University Court to enjoin attendance upon the class in natural history, but that ordinance, as I understand, had special reference to the University of Aberdeen, where attendance upon the class of natural history has been for a very long time a necessity. In Glasgow, however, the ordinance as regards the Master of Arts is somewhat peculiar, and that is a point to which I wish specially to draw attention. I have brought here a copy of the ordinances, which I shall submit to the Commission, and in them it is stated that in the three departments which fall properly under the Master of Arts degree there shall be two classes, but in the department of natural science there shall be only one; and the understanding amongst the professors, both in Glasgow and, I believe, also in Edinburgh, is that the limitation to one class of honours in science means, practically, that the candidate shall pass simply. We require two classes of honours in arts, and a pass is all that is requisite under the ordinances in natural science, so that hitherto there has been, one might almost say, no inducement to students to attend the classes in natural science. I have had three candidates for honours in the M.A. degree with physical science, and in two of those cases there was the most obvious disqualification. In one instance the man had attended no class whatever previously, and had simply read for six months, and I dismissed him very summarily. The other had attended very irregularly, I believe, but when I submitted a familiar object in natural history he did not know it, and him likewise I dismissed; but I believe that I was acting against the letter of the ordinance, and that he had a title to claim examination to the full extent.

9579. What is the condition of preparation of the young men entering the classes?—In the case of engineering students I have never met with one man who had any previous knowledge of geology, and I have therefore to begin at the very alphabet of the subject, and carry them on in such a fashion as is possible within 50 lectures, with the very unsatisfactory result that at the end I only got them to understand the merest elements of the subject. There is a belief that geology is, so to speak, a make weight for the certificate. They do not attach very great importance to geology, and this is simply the reflex of the common opinion amongst the great body of engineers in the country. As regards the medical students, they are deficient both in scientific training as a preliminary, and also in elementary education. As clerk to the Faculty of Medicine, and having charge of the preliminary examinations, I am very painfully aware of that circumstance, and the explanation of it is an exceedingly simple one. I have gone over the papers submitted to the candidates in the training schools for about 20 years, and I have ascertained that my inferences were correct upon the authority of various teachers in independent schools, teachers in the normal schools, and one of the inspectors; and I am I believe correct in stating that within the 20 years the standard of requirements has sunk very noticeably, in so far as Latin, Greek, French, and German are now omitted from the requirements in those training schools and normal schools in Scotland; that as regards mathematics the requirements have sunk for students in the normal schools from six books of Euclid to four; as regards the pupil teachers, from four books of Euclid to one, and algebra has disappeared altogether, unless one counts as algebra the permission given in the arithmetic paper to make use of algebra, if found more convenient, which is simply reducing algebra to an *alias* of arithmetic in place of an instrument of investigation. In the last examination, held in October, I find that as regards several of the candidates the preliminary examination for medical students in the University of Glasgow corroborated that, in so far that one man came to me and said that he did not know anything about algebra, he had never been taught it; and two others, whom I came upon accidentally, stated to me that they had only had their attention directed to algebra for three months prior to the examination, that is to say, it was not an essential part of the instruction in the schools where they had been trained.

9580. Those were young men who had been trained in parochial schools, and who ought to have been taught by the teachers and trained according to the previous standard, which you complain has been lowered down to something which is not efficient?—Yes.

9581. (*Dr. Sharpey.*) Did those candidates get through?—They did. At the same time, in both cases, they were men of unusual power, but a large number were rejected in algebra, and of those I can say nothing. Those men who passed upon a short preparation were elderly men of unusual power, otherwise they would have disappeared entirely.

9582. (*Chairman.*) Would your experience and memory serve you to state at what period exactly or about what period this deterioration in the efficiency of the instruction of pupil teachers in the training colleges commenced?—My recollection of the Blue Books which I have gone over is that the declension has been a very gradual one; that not merely have subjects been omitted, but the standard in those retained has gradually sunk. I cannot fix the date, and I do not think that any particular date could be fixed for any particular declension; it has been gradual.

9583. Can you remember the period when the training colleges were in those respects in a state of satisfactory efficiency?—About 15 years ago is the date that the teachers whom I have consulted fix as that representing a fair condition of training. Upon that point I am speaking from information received from teachers.

9584. A very considerable body of the students at Glasgow, both in the Arts department and in Science have received their preliminary instruction in elementary schools, have they not?—Yes.

9585. Therefore the lowering of the standard in the training colleges by which the masters of elementary schools were fitted for their functions has had the prejudicial effect which you have described upon the qualifications of students entering the University of Glasgow?—Yes; and perhaps I may be permitted to add to that statement that the Glasgow students are in a somewhat peculiar position relatively to the rest of Scotland, that in Aberdeen the students are drawn from a district in which the standard of excellence is maintained by the existence of the Dick Bequest Schools; that in Forfarshire, where I understand that these schools do not exist, nevertheless the Angus Club, and the competition with the Aberdeen district maintain a very excellent standard of schooling, and that in the neighbourhood of Edinburgh there are a great many endowed schools existing, and those competing with what one may call adventure schools have had the effect of maintaining a very good standard. Moreover the students at Edinburgh are a wealthier class, a better class socially than those at Glasgow. In Glasgow we have to deal mainly with those who come from the elementary schools of the west of Scotland, where there is absolutely no encouragement worth speaking of for the maintenance of a high standard.

9586. I gather from what you say that you consider the maintenance of a much higher standard of education and examination for pupil teachers, and a much more efficient and extensive course of instruction in training colleges, to be one of the necessary elements to the success of the University of Glasgow?—Undoubtedly.

9587. And anything which tends to lower the standard of the elementary education of the west of Scotland must have a very prejudicial effect upon the

J. Young, Esq., M.D.

23 Feb. 1872.

University of Glasgow?—Yes, and upon the medical profession, in so far as it is affected by those sent out from the University of Glasgow.

9588. Have you any remark to make as to the confusion of the functions of the Department of Education at Whitehall, and the Department of Science and Art at South Kensington?—I have made special inquiry into that, in fact I have made inquiry for a considerable time past, being specially interested in it, and the seventh article in my précis of evidence refers to that, which is in these terms: "This (the deficiency in elementary training) is due among other things to the decline of the Whitehall standard of examination, and to the means taken to prevent the two departments at Whitehall and South Kensington paying simultaneously for the same thing." As regards that, we have had several instances of the difficulty arising in consequence of a certain amount of inevitable collision between the two departments, and it arises in this way, that if a school goes on with a slight staff, a staff consisting of the head master and one or two assistants, such as he may choose to make use of, it may go on for a considerable time efficiently as an elementary school; but if at any time it is necessary to increase the staff by the apprenticeship of pupil teachers, then the teacher must surrender either the Whitehall Department or the South Kensington Department, and the letter which I hold in my hand is an evidence of the correctness of my statement. It refers to the teacher of one of the most flourishing schools in Glasgow, and I procured a copy of his letter from the secretary, Mr. Thomas Watson. "Saint Stephen's Parochial School. Sir, I am instructed to inform you that the above school having increased to such an extent as to necessitate Mr. Macaulay's taking part in the instruction of the pupil teachers, the managers are thereby precluded from participation in the grants from the Science and Art Department, and therefore no application has been made for form No. 168 (constituting committee)." This letter is addressed to the Secretary of the Science and Art Department at South Kensington. I may state that this collision is inevitable and that the object of it is to prevent the two departments of the Government paying for the same thing simultaneously; but an approach towards the removal of this obstacle is evidenced by a letter which the rector of the Established Normal School showed me the other day from Sir Francis Sandford, stating that a high-class certificate from South Kensington would be counted towards an improvement of the certificate from Whitehall. Of course my statements refer only to Scotland, the operations of the departments in England being under somewhat different regulations.

9589. Your conception is that everything relating to the normal training colleges and to the elementary schools should be under one department, whether it be scientific or elementary?—Yes, under one department.

9590. And that there should not be a confusion of administration by the interference of another department in elementary schools or in training colleges?—Precisely.

9591. Have those defects to which you have alluded had any prejudicial consequences upon the profession of civil engineering?—I believe that they, in conjunction with what I have to state presently, have had a good deal to do with the unfitness of the men from my point of view, when they enter upon the study of civil engineering; that is to say, that there has been no encouragement in the elementary schools, that there have not been competent teachers, even supposing that there had been encouragement, and that consequently men come to the Universities to learn what they ought to have learnt elsewhere; and as to the teachers we never reach to the higher grades of our subject, simply because we should be talking over their heads if we attempted it.

9592. But I understand that before 1856–7 the condition of things was much more hopeful?—At that time there was no certificate of engineering science, and the medical profession had not been subject to the regulation requiring attendance upon natural history as an essential part of their course, nor to a preliminary general examination, so that the data for comparison are to that extent defective.

9593. To what class are the popular lectures in the Andersonian and Mechanics' Institution addressed?—There is no special definition of the class as regards the Andersonian University, but the Mechanics' Institution, as its title implies, was primarily intended for workmen. In both cases the present auditors are not workmen, but men in the position of clerks, foremen, and the upper classes altogether of the working community, men in the receipt of incomes from probably 100*l.* up to 150*l.* or 200*l.* Divinity students attend those courses, because in the first place the number of lectures is smaller than in the University, in the second place the payment is less, and in the third place there is not the same amount of work required from them, so that those professional students receive an inferior *amount* of instruction to what, I think, should be required of them if they enter upon the subject at all. As regards the South Kensington payments, in Scotland these are confined entirely to the class of children whose parents' incomes do not exceed 100*l.*; shopkeepers are excluded. The heading of the paper is "Examination for the poor," and in one school in Glasgow all the scholars scored out the words "for the poor," because in Scotland "poor" means a pauper upon the parochial list. Other classes may obtain certificates, but, as an example of how very small the encouragement is that a certificate holds out, last year 642 schools came under the Science and Art Department in England, 251 came under the Department in Ireland, and 50 in Scotland. Of course individual students are at liberty to go up for this examination without professing themselves members of any school, but the number of schools is the important point.

9594. You consider that regulation to have a prejudicial effect in Scotland, by limiting to a very great extent indeed the number of students?—Yes, the encouragement held out is not sufficient; and as a practical illustration of what I have said, I attempted three years ago, while the college was in its old place in High Street, to form classes of the teachers and pupils for anatomical and physiological demonstrations. I offered to give six demonstrations upon Saturdays, charging 2*s.* 6*d.* for each pupil and the teacher that came with him, if they would follow Mr. Huxley's little "Handbook of Physiology." I would have gone through lessons with them, demonstrating them each fortnight, the payment to go to the funds of the museum. Two schools professed their willingness to come, but those were schools which had no immediate connexion with the department, and a large number of teachers whom I had personally solicited to avail themselves of this opportunity declined, on the ground that they could make nothing of it, that they were already overburdened with work, and could make no increase to their emoluments, and therefore it was not worth their while. Some of them declined on the ground which I have already referred to, namely, that they had already pupil teachers apprenticed to themselves, and were therefore debarred from going to South Kensington, being already under Whitehall.

9595. The teachers have been also taught to work for what will pay?—Yes. And I may mention another case which is within my own knowledge, of a teacher, not eminently successful certainly in any department that he has attempted, who organized a school in a poor district. He offered to give 30 lectures on physiology to those who might choose to come, they paying 2*s.* 6*d.* for the course, 1*d.* a lecture. He had about 20 or 25 pupils, and a friend of mine said to him, "What motive have you for this, your room rent will very nearly absorb your fees." He said, "No matter for that, I shall clear something out of this." He counted on cramming a certain number, and being paid "for the result" by the Science and Art Department. So that in reality this was a barefaced piece of cramming, simply for the sake of getting money. It was not getting money for what he had taught, but

J. Young, Esq., M.D.

23 Feb. 1872.

teaching for the sake of making money. The interjectional remark which I have put in my précis as regards the profession of engineering has reference specially to a paper which I submitted to the Institute of Engineers in Glasgow, and of which I have brought a copy, urging upon them the propriety of their procuring a charter, or whatever might be necessary to give them some title, whatever it might be, and a fixed position in the profession. At the present time I, in respect of having been upon the Geological Survey, and having taken an interest in mining matters, am at liberty, if I choose, to put C.E. after my name; and a large number of men who figure as civil engineers are not a whit more competent than myself to discharge the duties of such a profession. I advocated that course very strenuously before them, but the objection was taken that this was something like the formation of an old guild, which might be a very good thing under the circumstances. At present, in consequence of the profession of civil engineers having taken no active interest in maintaining the standard of education within the profession, and in consequence of there being no encouragement in the elementary schools for the careful preliminary study of science, I consider that the profession of engineers is in a worse position scientifically than the profession of medicine.

9596. Taking into account the declension which has occurred in the extent and the efficiency of the instruction in the training colleges, is there a sufficient number of teachers qualified to give, in the elementary schools, that extent of scientific instruction which is desirable, or able to take charge of science classes through the country?—There is not; and notably in my own district, in the western part of Scotland, the teachers are very unfit, as a body, to undertake special classes in science.

9597. From what sources are teachers at present supplied?—The training schools furnish the certificated teachers, and the Universities by their degrees furnish a number of men who, from the very fact of their possessing a degree, are accepted by the South Kensington Department as qualified teachers of science; but in Glasgow certainly there has been only one degree which gave a science qualification, namely, that of M.D. Lately an attempt has been made to establish a degree of science under the title of Bachelor of Science. As regards that degree I may state my own individual opinion. The details of it are published in that report which I have placed in your hands at page 25. The degree has been established in three departments, in law, in natural science, and in engineering science. In natural science there are two courses, one in biological science and the other in geological science, and as regards those two with which I am specially connected, my regret is that although my name appears as one of the committee, still the requirements in the direction of arts are far too great. Thus in biological science there are five subjects stated, namely, chemistry, anatomy, physiology, zoology, and botany, the candidate having it in his power to select any four of them, and four classes in the arts curriculum. In geological science he may select geology, chemistry, zoology, and the higher natural philosophy, with four classes in the arts curriculum, and the option of geodesy at the hands of the Professor of Astronomy. The requirement of four classes in the arts curriculum seems to me and to others to be somewhat excessive, taking into consideration the fact which the Universities must now not lose sight of, namely, that men enter upon the profession of science in a very different spirit to what they did many years ago. We must remember that many enter upon it purely as a trade, if one might use that word without disparagement. I have no other phrase to convey the idea. It is all very well for the Universities to say, Yes, but we must secure a higher standard of education from those men. If the Universities stand upon that ground they will soon be left high and dry, and the whole scientific education of the country will drift past them. Other sources of instruction will arise, and the Universities will cease to take part in the general scientific instruction of the people.

9598. Would you be disposed to increase the facilities in the Scottish Universities for training science teachers by means of practical classes?—My wish has been for some years past that we should have it in our power to institute classes for the instruction of the teachers. I thought at first that it might be done in the way I attempted myself, but that is not a sufficiently systematic procedure. And I am hopeful of seeing established in the Scottish Universities an organization similar to that which was made use of at South Kensington last year, namely, that we should receive a certain number of the teachers as pupils for a certain period of the year, that we should give them detailed demonstrative instruction, and that upon the teachers of the Universities should be thrown the responsibility of the certification of those candidates. It was perhaps impossible in the old building, but it is quite possible in the new building. There is abundant space in connexion with the Hunterian Museum and the class of natural history for the instruction in that way of about 30 men. The only want is assistance. It is perfectly impossible for me to undertake such a thing without having some kind of assistance, whether directly in connexion with the University, or, as seems to me more desirable, directly in connexion with the Science and Art Department. In other words, that the University should give the space for this instruction, and that the Government should give the means for carrying out a systematic course, leaving upon the teachers a very large amount of responsibility as regards the result.

9599. Your intention would be not to give simply theoretic instruction by means of lectures, or in classes or from books, but likewise to give practical instruction to the students in manipulation by means of specimens or otherwise?—Precisely; we have far too much of lecturing at present, and far too little of demonstrative examinations.

9600. In the course on biology are experimental and comparative physiology sufficiently attended to?—I speak upon this subject from my own experience as a teacher of zoology, and I find that at the present time there is not a sufficient amount of experimental physiology taught. In the University of Glasgow there is no assistant provided to the Professor of Physiology or Institutes of Medicine by the Universities' Act; and although there is now a laboratory fitted up for experimental physiology in the building, still we have not the power to get it put into such effective use as might be desired. The emoluments of the Chair of Physiology are too small to induce anyone who is not drawing an income from other sources to undertake those duties, and therefore the teaching of zoology suffers, because as my students are supposed to have, and so far as I can they are compelled to have, had a previous course of physiology, they come to me unable to follow the teaching if I go beyond the simplest facts. From that point of view I think that both in the way of experimental and comparative physiology, and in the way of demonstrations in organic chemistry, there is a very great want in the University teaching in Glasgow at any rate. That question I may remark, as regards professional and non-professional teachers, is one that has engaged a good deal of attention amongst the Scottish Universities. All teachers appointed by the Government since the date of my own Chair, in 1807, have received on the average the same emoluments; and as a consequence, in such a Chair as the Institutes, a man is obliged to enter upon professional work to make his income sufficiently good, and that is a thing which very many of the Scottish professors feel to be a misfortune, both as regards science and the special training of the medical students.

9601. In almost all the scientific subjects I understand that there is a lack of assistance to the lecturers?—Yes. In my own department in zoology and geology I suffer very much from the want of some one who

J. Young, Esq., M.D.

23 Feb. 1872.

would undertake especially the histological course, requiring a great deal of time to be expended upon the preparation of the specimens, and upon the instruction of the students in the method of preparing those specimens. In geology I am practically at a standstill, as regards the special training of engineering students, from want of some one who could undertake a sufficiently good course of instruction in mining. For three years at my own expense I procured the assistance of a medical student who had come to the profession from the pit, who gave a course each year of 10 or 12 lectures upon practical mining. I paid him, and I supplied him with the necessary plant and all the expenses required for taking the party out to the field for practical instruction. At that time I made an earnest appeal to the people of Glasgow to assist me towards the erection at least of the first elements of a mining school, and I applied in vain. I have not been able to make any further progress towards realizing this, and obviously it was wrong of me to go in for this expense annually out of my own pocket, as my own allowance was sufficiently small. I have brought with me a copy of that application that the Commission may see it (*delivering in the same*). It was gone into very carefully by means of the public press. To this day, however, there is no effort made towards realizing my wish, and the technical schools which have been recently contemplated in Glasgow do not at present embrace it within their sphere.

9602. Your impression is, therefore, that improvements such as you contemplated are not at present to be expected to originate in local intelligence or liberality?—Exceptional liberality may be met with; but where you have to deal with a very large number of proprietors, as I have in Lanarkshire, men of various social positions, I find that there is not a sufficient appreciation of the practical benefits of scientific teaching. In fact, remarks which were made to me by men of very good position as regards wealth showed that they were utterly unfit to appreciate the direct benefit to themselves of such courses as I proposed; and I attribute this defective comprehension simply to the fact that our elementary and even our secondary schools do not distribute through the people a sufficient amount of scientific instruction.

9603. Taking the managers of the large collieries and ironworks of Lanarkshire, what proportion of them have had elementary scientific training, either in an elementary or in any secondary school, and what proportion of them have fitted themselves, by independent self-sustained studies, to pass an elementary examination in science?—A very small number indeed. I should not like to say that there were none, but a very small number indeed are properly qualified to undertake the duties that are at present committed to them. They have a routine practice, and I quite admit that the pit or the workshop is the best place for learning a certain amount of their duty; but beyond the rule of thumb that they have there learnt they are perfectly incompetent to deal with anything that may arise. In any emergency they are helpless; they are obliged to consult a civil engineer or a mining engineer; and as I have already said, the majority of the civil and the mining engineers are not in a position to give them certain assistance.

9604. If, therefore, the Government were in any mines' regulation bill to require an elementary examination of the managers of collieries in scientific matters, such examination at present must be of the very humblest character?—Of the very humblest.

9605. Otherwise the great majority of the present managers of collieries would have to be dismissed?—The present managers of collieries are perfectly competent for the major part of the duties that are imposed upon them; but the value of the pit and the safety of lives of hundreds may depend upon an unforeseen chance, and with that they are incompetent to deal. And even in the preliminary step of the investigation of a mineral field, there are recent cases within my own knowledge where a man accredited as a competent adviser, and much resorted to as an adviser, has betrayed the most lamentable ignorance upon what any of the pupils from Jermyn Street would have been able to have set him right, the consequence being needless expenditure and ludicrous mistakes to anyone who knew anything about geology.

9606. (*Sir J. Lubbock.*) What are the vacations in the University of Glasgow?—They vary according to the departments. In the arts, law, and divinity, the session is confined to the winter months, that is to say, there are six months of lecturing and six months of vacation. In the medical department the greater number of the classes are during the winter months, with a six months interval; but anatomy, botany, chemistry, and zoology are carried on during the three summer months. The clinical instruction in the hospital continues during the summer also. Medical jurisprudence is at present a winter course, but we hope that it will be before long placed in the list of summer subjects, so as to leave the winter more free for the students.

9607. In fact, a student at the University of Glasgow need not attend at all during the summer months unless he is disposed to do so?—In the medical curriculum there are two summers during which he must give attendance. Two out of four summers that are required for the degree must be spent in Glasgow. In the arts curriculum there is no attendance in summer.

9608. Does that arrangement practically admit to the advantages of the University a certain number of students of a lower class than those who generally attend the English Universities?—Yes, it does in this way, that a large number of the young men who hold subordinate positions in schools are enabled to come up for the winter months, and return to their school duties during the summer and autumn. In engineering it is in many respects a very useful arrangement, because it admits of a student attending lectures during the winter, and returning to the workshop during the summer.

9609. Do artizans in Scotland practically make any use of the University of Glasgow?—None whatever. I have referred to my assistant in the matter of mining. He attended the medical classes during his first two winters, and during the intervening summer he returned to the pit and wrought in the pit, thereby procuring sufficient money to carry him on for the rest of his course, and he is now a very distinguished member of the profession; but those are exceptional cases altogether. One may say that they almost prove the rule that artizans do not avail themselves of the University.

9610. (*Dr. Sharpey.*) Has it been in contemplation to divide the duty at present assigned to the Chair of Natural History into two divisions, and place them under two professors as in Edinburgh?—At my instance the question has been raised and discussed for a good many months past, and I have got a certain amount of encouragement, but no one has yet taken any practical step towards helping me, with one exception, a gentleman who has promised to give a certain sum of money if the coalmasters and ironmasters fail to establish a Chair of Geology. If they succeed in doing so he promises to give the same sum of money to increase the emoluments of the Chair of Zoology. But at the present time the movement as regards the division of the Chairs is in abeyance for the reason I have already stated, that the community, even those who derive their incomes specially from mining pursuits, do not realize the importance of the question. And they cannot appreciate the real detriment inflicted by the continuance of the present state of things upon the University teaching. In the first place possibly I have no right to make this remark seeing that I voluntarily undertook the duties of the Chair; but I now realize the fact that it is absolutely a sacrifice of the teacher, it destroys altogether his chance of ever doing original work, he has no time for it, and if he had, he has no assistant, and the object of a University is to encourage, as I take it, original work, both for the advancement of science

J. Young, Esq., M.D.

23 Feb. 1872.

and actually for the benefit of students; for I know from my own experience that when, by a sacrifice of other duties, I have confined my attention to a particular point, my students were always better instructed during the time that I was specially engaged in that way, even although it was a pure technicality. But, with the increase of the duties in connexion with the medical classes, that is absolutely out of my power, and it is simply throwing away a weapon to compel a man to hack backwards and forwards from one subject to the other, paying inadequate attention to both subjects. I speak very feelingly upon this matter, as it is a very painful prospect to a young man that his reputation may after years of work be only that of a more or less successful "coach."

9611. It was hoped, was it not, that funds might be got together in Glasgow from private contributions which might be supplemented by a grant from the state for a Chair of Geology?—That was the scheme which I put forward, but at present there has been too little response to my solicitation; everyone expressed general approval, but no one offered to put his hand in his pocket, or rather, abundant offers were made if somebody else did it first; and so I have gone from pillar to post for a good many months. Now I am hopeless of it. I have the matter upon the books of the General University Council for discussion in April, and then I mean to intimate the possibility of my discontinuing longer to give the two courses distinct, as at present, for in Glasgow the financial argument will be perhaps more readily appreciated than any other. I am teaching at present at the rate of 13*s.* a lesson, which is essentially an unwise financial arrangement. It has seemed to me that probably there might be more hope of success in this direction if the Government were to hold out the promise of doing the same thing for Glasgow as has been done for Edinburgh. And upon that point I may remark that by that assistance to Edinburgh, as it seems to me, the Government has committed itself to a principle of some importance to such as myself. When my Chair was founded it was obviously, although it was not stated, for the advancement of science. The late Sir James Simpson prepared carefully tabulated statements, showing that every other Government department had improved as regards finances except the professors in the Universities during the last half a century. The endowment of the Edinburgh University Chair of Geology is, if my recollection is correct, about 600*l.*, that is to say, the Government have given 200*l.* in support of another endowment of 400*l.*, and have thereby conceded the propriety, as it seems to me, of the endowment being larger. They have, therefore, elevated one Chair in Scotland to a very great and disproportionate position as regards endowment above other Chairs of exactly the same nature. Had the emoluments of my Chair been better, a very much better man than myself, Professor Wyville Thomson, would have obtained the appointment.

9612. (*Chairman.*) Is there any other observation which you would like to make to the Commission?—I do not know if it is competent for me to speak of the technical movement in Glasgow; but as I was requested by some of the promoters of that scheme, I myself being amongst the number, to represent one point regarding it, perhaps I may be allowed to do so. I stated that my wish was to give facilities for the instruction of schoolmasters within the University walls, that is to say, the University not directly benefiting from such instruction, no matriculation fee being required. The scheme of the technical schools was at first suggested as an appropriate addition to the University, but to that I took very strong exception, and the proposal has been departed from, as the technical school is, in one sense, an enormous addition to the work of the University; but as regards the training of workmen and managers in certain departments, the number of them to be increased as the funds increase, the advocates of that scheme are at one with me in the belief that no success will be satisfactory, unless, in addition to the compulsory education which is proposed by the Lord Advocate's measure, some clause be introduced so as to make sure that in every parish in Scotland there shall be an effort, if no more, towards giving scientific instruction in the elementary schools; and I am at present prolonging my stay in town for the purpose of seeing one or two members of parliament to endeavour to get this introduced if possible, so as to save Scotland from the battle which I believe was fought in the London School Board, and which may be fought in one or two towns in Scotland, but in the rural districts or small towns will never be dreamed of.

9613. Has it ever occurred to you that in any particular branch of engineering or mining which derived direct benefit from the introduction of scientific instruction, the chief managers might not, in conjunction with the requirements of the Government as to certificates for managers, likewise be required to contribute something towards the funds necessary for the education of those managers?—I did consider a somewhat similar question, but the conclusion that I came to was that it would be far better if any opportunity for instruction existed anywhere, I do not say in the University, but anywhere, that the Government should insist upon a certificate, and leave them to find out the place where they could get instruction—that it would bring the University into a dangerous collision with the men, who are already very timorous upon the subject of monopolies, and might in the long run injure the position of the Universities by attempting to force them upon a class who were not willing to receive their aid. It is simply a question of class prejudice, which I think would be better avoided.

9614. (*Dr. Sharpey.*) You would propose to require a certificate of scientific knowledge on the part of persons who would undertake the superintendence of collieries or mining establishments?—I should be glad to see such a requirement introduced into the Mines' Regulation Bill, because as a teacher said to me regarding Latin and Greek in the teacher's examination, "The Government has only to require it, and the supply will be forthcoming immediately." Such a compulsory clause in the Mines' Regulation Bill would I believe promote very effectively the division of my Chair. [*See* APPENDIX V.]

The witness withdrew.

Adjourned to Wednesday next at 12 o'clock.

6, Old Palace Yard, Westminster, Friday, 1st March 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

WILLIAM SHARPEY, Esq., M.D., Sec. R.S.
GEORGE GABRIEL STOKES, Esq., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, Esq., M.A., F.R.S.

Rev. JOHN TULLOCH, D.D., examined.

Rev. J. Tulloch, D.D.

1 March 1872

9615. (*Chairman.*) I believe you are Principal of St. Mary's College in the University of St. Andrews?—I am, and Senior Principal in the University.

9616. Will you have the goodness to describe to the Commission how the scientific department of the University is constituted?—It is constituted in this way: it consists of five Chairs, comprising mathematics, natural philosophy, chemistry, natural history, anatomy and physiology.

9617. How many classes are taught by the professor of mathematics?—He teaches three classes.

9618. Will you describe to the Commission the duties of the Professor of Mathematics?—In the junior class, which is generally attended I believe by first or second year's students (I suppose chiefly first year's students), he teaches six books of Euclid, algebra as far as simple equations, including ratio and proportion, and the theory of arithmetic. In the second class he goes on with algebra, plane trigonometry, the application of algebra to geometry, trigonometry and conic sections. In the third, or senior class, for three days a week he teaches analytical trigonometry, analytical conic sections, and differential and integral calculus.

9619. Has he any assistance in this course of lectures?—He has no assistance at all.

9620. What age are the students attending those classes?—The junior students are many of them very young, I should say ranging from 14, which is perhaps the extreme junior age, to 18 or 19, and occasionally we have a schoolmaster coming up from the country considerably older even than that.

9621. In the senior class, would you say that very few exceed 18?—I should think the average is not above 18.

9622. During how long a period does the session extend?—Six months; from the commencement of November to the end of April, with a fortnight's or 10 days' vacation at Christmas; it includes from Christmas Day to New Year's Day.

9623. Will you have the goodness to give us similar information with regard to the professor of natural philosophy?—He teaches one class, lecturing seven hours a week. His subjects are the properties of matter and of force, including inertia, gravitation, molecular forces, laws of motion, conservation of energy, &c., dynamics or mechanics, including hydrostatics and pneumatics, sound, heat, light, electricity, astronomy, and meteorology.

9624. Are all students who propose to graduate required to attend the lectures of both those professors?—Yes, of both—and also all students who go into the Church are required to attend both.

9625. Can you give us any general information with respect to the professorship of chemistry?—The professor of chemistry teaches one class, lecturing an hour each of the teaching days, that is five days a week, and he has a practical class, lecturing three additional hours. The subjects taught are chemical physics, including the chemical relations of cohesion, adhesion, heat, light, and electricity; chemical philosophy, including the atomic theory; the non-metallic and metallic elements and their compounds, and organic chemistry. This professorship is in some respects peculiar. It was a private foundation by Mr. Grey, and the first professor was appointed in 1840.

9626. This professorship was founded by private endowment, but is it now considered public?—Yes, it is now a regular Chair in the University, and also since the Universities' Commission a regular Chair in the College. There is a distinction in St. Andrews which exists in no other Scotch University; there are two colleges and the University. The Professor of Chemistry always attended the University meetings, but there was a doubt about his being entitled to attend the College meetings and vote. Now he takes his place in the college meetings, and in the University meetings, the same as any other professor.

9627. Is attendance upon the lectures of the Professor of Chemistry required for the arts degree?—Now again it is. The University Commissioners put the Chair of Chemistry out of the curriculum. I do not know that I can state all the grounds upon which they proceeded in coming to such a decision; but after considerable agitation in the general council, or general convocation of graduates, it was replaced in the curriculum by the University Court; only we granted this indulgence in placing it in the curriculum, that students who had entered under the old system were entitled to finish their course without being compelled to go to the class of chemistry. The examination in the degree of arts was not to include chemistry till students who had entered under the old system had completed their course.

9628. Then a certain degree of acquaintance with chemistry is now required for a degree in arts?—Yes, it is now required.

9629. The University also has a professorship of natural history. Can you give us any information respecting that Chair?—Our Chair of Natural History is in a peculiar position. It was originally the Chair of History, which was interpreted to mean civil history. The University Commissioners gave it, as we all believe, a very extraordinary name. They gave it the name of the Chair of Civil and Natural History. That is now the legal designation of the Chair. The Chair does not belong to the curriculum, and it has not been practically a useful Chair ever since I recollect, and my recollection extends to the period when I was a student, as well as since I became officially connected with the University. Dr. Ferrie was the professor when I was a student, and he lectured occasionally upon general history. The class was attended for three or four lectures, and then it ceased. Dr. McDonald, the present professor, has occasionally managed to get a class, but from many causes the class has not been regular.

9630. Then you would say that the University at present gives no instruction in any branch of natural history?—I cannot say that it does. The Commission will perhaps allow me to explain that the Chair is not only peculiar as to its working, but it is peculiar as to its patronage. It is in the hands of the Marquis of Ailsa, who may appoint any person he pleases to the Chair. The University has no control over the appointment; and this is a matter very well deserving attention. We have three Chairs, unhappily, as we think, in this position, being entirely in the hands of private patrons.

9631. Is this a Chair of the University, or a Chair belonging to one of the two colleges?—It belongs to the United College, but all the Chairs of the two colleges are also Chairs in the University. It may be said, perhaps, in further explanation, that any class in St. Andrews not belonging to the curriculum, that is to say, not required for the degree, would in any circumstances, at least such as we have hitherto known, have a difficulty in procuring a good attendance.

Rev. J. Tulloch, D.D.

1 March 1872.

9632. What classes has the Professor of Anatomy and Physiology?—He has one class, a semi-popular class, upon physiology and hygiene and he teaches without any fee. I strongly recommend my students, who are theological students, to attend his class, and the result is that in the latter years of their course, when they are not so hardworked as in the beginning many of them avail themselves of his instruction, and as he teaches without any fee, and teaches in the afternoon, the result is that he has had since he was appointed, a very fair class, averaging about 30. I may observe that the first part of the course is occupied with the study of the healthy tissues and their functions; the second part with the several systems of the body, for example the osseous, muscular, vascular, respiratory, cutaneous, nervous, and digestive systems, &c. During this course special consideration is given to the subjects which bear upon the hygiene of individuals and of communities, for example, nutrition, growth, exercise, physical education, food, drink, air and water, clothing, ablutions, ventilation, drainage, climate, occupations, &c. The class has been highly useful to young clergymen and others.

9633. (*Dr. Sharpey.*) Is that also a private foundation?—It was originally a private foundation, and it goes by the name of the Chandos Professorship of Anatomy, but I forget about the special circumstances of its origin.

9634. (*Chairman.*) Has this professorship a special endowment attached to it?—Yes, it has a special endowment attached to it; I think the endowment is about 330*l.* a year.

9635. Is this class chiefly attended by senior students? —Yes, chiefly by senior students.

9636. Would you wish to add any further details with respect to the course of lectures delivered by this professor?—I may observe that he devotes his lectures greatly to the hygienic aspects of his subject, and he impresses very forcibly upon the students the necessity of attending to their physical health and means of recreation, and diet, and gives his lectures, in short, as interesting and practical a character as he can.

9637. Is there any examination connected with his course of lectures?—No, examination, except what he himself may hold in his class; it does not enter into the curriculum.

9638. Is the University provided with a museum? —It is.

9639. What is the general character of the museum?—The museum, I understand, is now very interesting and very good. It is mainly a local collection, but it has recently received a considerable addition. Dr. McDonald, our Professor of Natural History, has added to it his collection, which is of considerable value. After some negociation we accepted this collection about 10 months ago, and it is now in progress of being added to the museum.

9640. This museum is a general museum, is it not?—Quite so.

9641. Is there both a geological collection and a collection of all the Departments of Natural History?—All the departments are, to some extent, represented. There is a good collection of the Dura Den fossil fishes—Dura Den being in the neighbourhood.

9642. It also comprises, does it not, subjects connected with antiquarian researches?—Yes; many gentlemen belonging to St. Andrews have been to India and brought home objects of curiosty and interest and they have been deposited in the museum.

9643. Has the University any laboratory, or collection of apparatus available for any of the courses of lectures?—The Professor of Chemistry, the Professor of Natural Philosophy, and also the Professor of Physiology have their respective apparatus, which I believe is very inadequate; and sums are granted from the University funds, year by year, for the purpose of adding to the apparatus and restoring what may have been wasted. These sums are small, and are believed by the professors to be very inadequate for the purposes required.

9644. Has the University any prizes devoted to the encouragement of scientific education?—Yes; Mr. Duncan, our late Professor of Mathematics, left a sum of money which produces 14*l.* per annum, for the study of mathematics. There are the Carstairs' gold medal, and two further Carstairs' prizes of books, value 2*l.* and 3*l.* respectively; and quite recently, only about 18 months ago, Dr. Neil Arnott presented us with 1,000*l.*, which is likely to be of great advantage in promoting the study of physical science.

9645. Has the University no exhibitions or anything in the nature of permanent scholarships?—Not for science. We have two or three scholarships for classical study.

9646. Are you of opinion that the University of St. Andrews possesses any opportunities of extending its scientific teaching?—Some of us have been strongly impressed for some years with the possibility of turning to account our vicinity to Dundee, which is likely to be much more intimate than in former times. Although Dundee is only about 14 miles of distance, there has hitherto not been a great deal of intercourse between it and St. Andrews, owing to the Frith of Tay intervening, and the fact of the two towns being very distinct, with few interests in common. But now that a bridge is to be thrown across the Tay, and from other causes, there is likely to be more connexion between the two places. In fact during the last 10 years this has been growing. The Dundee merchants readily send their sons to the College Hall, which is a place of residence for students attending the University, which we, alone of the Scotch Universities, have succeeded in establishing. It was a sort of restoration of the old collegiate residences which had disappeared in the course of time, and the Dundee merchants have contributed to its prosperity by sending their sons to it. Mr. William Edward Baxter, now of the Treasury, sent two, if not three, of his sons, and they have all expressed themselves highly satisfied with the result. The importance of extending our academic operations so as to benefit the Dundee population, has received during the last winter a definite impulse from the fact of the Durham University having extended its operations to Newcastle. As yet we have done nothing beyond preparing a private memorandum on the subject, with a view of being submitted confidentially to some of the more wealthy Dundee merchants. By *private* I mean that the memorandum has not as yet been formally considered by the University, and that the proposed plan of scientific study which it suggests is merely tentative, and intended to show that we are ready to meet the Dundee people in any way that may seem most likely to advance the higher instruction in Dundee, and most suited to their necessities. A beginning, it was thought, might be made by evening classes.

9647. (*Dr. Sharpey.*) What class of students would you expect to attend those classes?—We should expect the artizans to some extent.

9648. (*Chairman.*) Are there any suitable buildings available for the purpose at Dundee?—There is a large institution lately erected in Dundee, which has been pointed out as possibly available for such a purpose, called the Albert Hall. It contains, I believe, a public library, and is of recent erection. It is a large and handsome building.

9649. Has the University of St. Andrews the means of promoting the establishment of a scheme of this kind by pecuniary assistance?—We have scarcely any means of doing so. We might contribute to a small extent. There have been two proposals as to the mode of carrying out the idea, the raising of an annual fund, or of a capital sum. I believe that the Dundee people, so far as they have expressed any opinion about it, incline rather to the latter plan. They think that it would be more easy in Dundee to raise a capital sum, and supposing they did raise a capital sum, it is barely possible that we might afford something like 1,000*l.* from our University funds, but that is a project which I have no authority for saying has been even suggested, and still less approved of. We have University funds, and this might be recog-

Rev. J. Tulloch, D.D.

1 March 1872.

nised, if the plan were likely to succeed, as a fair mode of applying a portion of them; but we have no such funds ourselves to carry out the plan without assistance.

9650. Have no steps been taken in Dundee itself, so far, to ascertain what funds you could find?—Steps are being taken. I may mention that the matter has been for some time privately before Sir David Baxter, who is very well known as one of the most influential and wealthy men at Dundee, and many others are indisposed to move until it is ascertained what he is likely to do. There is plenty of money in Dundee if it could be got.

9651. Does the principle of affiliating colleges or institutions in Dundee through the University find favour at St. Andrews?—Yes.

9652. Can you give the Commission any information with respect to the funds at the command of the University of St. Andrews?—Yes. Our capital fund at this moment at St. Andrews is about 21,000*l.*, and we have the annual revenue of this capital sum. Then we have the matriculation fees, averaging about 170*l.* or 180*l.*, and we have graduation fees, which I should think, taking them all together, may reach the sum of between 400*l.* and 500*l.* a year. This is chiefly from the 10 medical degrees that we grant annually.

9653. (*Professor Stokes.*) What may be the number of students that enter every year?—That varies considerably. The average number of students for some years has been, I should say, from 170 to 180. This is the average of the whole of the students in all degrees of progress.

9654. (*Chairman.*) Does each student pay a matriculation fee annually?—Yes, they pay 1*l.* annually, as in Edinburgh and the other Scotch Universities.

9655. Have you any other sources of income?—We have a special source of income, but it is not to be confounded with the ordinary income of the University. We commuted our right to books at Stationers Hall for the University library for 600 guineas a year. This sum is all spent in books annually before being paid. We send our accounts to the Treasury, and we receive payment for books to that extent. We spend more than this sum of course. I cannot say exactly how much more, but our library account is considerably larger. We have librarians to pay, and the binding of the books to pay. We have always considered it doubtful whether we are entitled to bind our books out of this parliamentary grant. Strictly interpreted, it is given for new books. We get our foreign books mostly bound, and we expend a considerable sum otherwise for binding English books.

9656. Is that the whole of the income of the University?—That is the whole of the income, I should say, of the University, as apart from the colleges. In St. Andrews, as I have already said, we have a collegiate system unknown in the other Scotch Universities; the colleges have a distinct foundation, and have their own revenues, just as is the case in the English Universities.

9657. And are they more wealthy than the University?—No, they are much poorer, because they have more demands upon them. The endowments of the Chairs, so far as they are endowments, irrespective of small sums from the late parliamentary grant and the old Queen Anne's bounty grant, come from the college revenues.

9658. Is none of the University income applied to the payment of the Chairs?—No; we are distinctly excluded by the late Commission from doing so. If we were to appoint a professor to do special work in the library, as has been done at Glasgow recently, where one of the professors has been highly useful in re-arranging the new library in their new buildings, we may pay a professor for the special work for which we have appointed him, but by an ordinance of the late Commission we are expressly excluded from paying him anything from the University funds, in consideration of his professional position or duties. In so far as the endowments in the colleges are concerned, the payments made to each Professor are statutory, and he receives what belongs to the Chair from immemorial usage, or as settled by the late Universities' Commission.

9659. (*Dr. Sharpey.*) You appear to have an income of nearly 1,300*l.* a year?—I should think we have about that.

9660. How is it all applied?—We have all the library expenses; we have two librarians and very frequently an assistant besides in the library. We have moreover an allowance to a superannuated librarian, and porter's wages, &c. This is a charge of about 300*l.* a year. Then we have the cost of binding books, printing, advertising, &c., about 200*l.*, and all the expenses of graduation, about 170*l.* or 200*l.* We have sums for class apparatus, about 140*l.*, and prizes 50*l.*, and further public burdens and many miscellaneous payments, say another 150*l.*

9661. (*Chairman.*) Are the expenses of examinations defrayed out of this fund?—Yes, all the expenses.

9662. Has the University at present any surplus funds available for the extension of its teaching or for other purposes?—At present we have a balance in our favour, I mean that we are adding gradually to our capital stock, year by year; but when I mention this, I ought also particularly to mention that we have some heavy charges in prospect, which it is important should be kept in view. We have been applying during the last 10 years and more for an extension of the library accommodation. When Mr. Ward Hunt was Chancellor of the Exchequer and Mr. Mill was our rector we had the matter all but settled. We were to receive an extension of the library at a cost of 5,000*l.* to the Government. Our argument with the Government was that although the University was primarily interested in the books, yet they were a public trust, used for public purposes, and aided by a parliamentary grant, and we thought that if Parliament gave money for books, year by year, they ought to provide the means of keeping them properly. Since Mr. Lowe's succession to the office of Chancellor of the Exchequer, I need scarcely say that we have not succeeded in obtaining our grant, and the result has been that we have agreed to lay aside as much money as we can for a certain number of years to form a reserve fund for extending the library, hoping that we shall still get a portion of the money from the Treasury. They made what we thought an extraordinary proposal, that we should suffer a diminution of our annual 600*l.* to the extent that would gradually pay up the 5,000*l.* This was the last proposal, and we did not see our way to accept it. I had a talk with Mr. Ayrton on the subject when he was in St. Andrews about a year ago. I took him through the library and showed him everything, and pointed out how terribly confined we were for room, but he did not hold out any prospect of our getting the means of extending it from Government. I should mention also that we are threatened with a charge upon our funds arising out of the circumstance of the University having formerly rented the Crown teinds or tithes in the neighbourhood. A great many difficulties have arisen in connexion with these Crown teinds in Scotland, and it is unnecessary I should go into all the details of an intricate subject. But the result is that the Government, or the Treasury, through their local officials in Edinburgh, have lately made serious demands upon us in consideration of teind alleged to have been unpaid for stipend to the parish minister while we held the lease of the Crown teinds, and at this moment the matter is unsettled. We have had many negotiations with the Treasury, and certain claims have been settled, but others remain unsettled. This may possibly prove a heavy charge upon our funds.

9663. Did you make any profit from having the teinds?—We made a profit at that time, but we expended all that we made for public or University purposes, and this is the hardship of the claim now made.

9664. Is the University library a very extensive one?—It is a large library, consisting of about

Rev. J. Tulloch, D.D.

1 March 1872.

110,000 volumes. We have been at our wits' end for room for years.

9665. Is much use made of the library ?—A great deal of use.

9666. Are students and the members of the general council admitted to the library ?—Yes, quite freely.

9667. Is that privilege given to any except persons connected with the University ?—We allow a limited number, who apply to what is called the library committee, and they receive permission to read the books.

9668. (*Dr. Sharpey.*) Do you extend that privilege to visitors ?—Yes, we are very liberal to any literary or scientific strangers in the town. Mr. Huxley, for example, used the library largely last summer.

9669. (*Chairman.*) Has the University any buildings except this library ?—It has the college buildings.

9670. Do the buildings which you are speaking of now belong to the colleges and not to the University ?—They do; those buildings are not the property of the University, but the library is the property of the University. I may mention generally, about those buildings, that it is only within the present century that the Government has taken up the charge of them. The Government took no interest in the University for a long time, and the colleges themselves had no funds to repair the buildings. The result was that the United College buildings fell into a state of great dilapidation, and remained so for many years; it is only I think since about 1826 that public opinion has pressed the subject upon the Government; and they now have the charge of all our buildings. We have no means of keeping them up ourselves. In so far as the maintenance and repairs of our buildings are concerned the Government is liberal enough, but when we come to want any special extension, such as this of the library, we are met by the greatest possible difficulties..

9671. Then we are to understand that the Government keeps the library, so far as its present structure is concerned, and the college buildings, in ordinary repair ?—Yes, and with respect to my house, which is the only collegiate residence now in the University, they extend the same favour to it as a part of St. Mary's College.

9672. Has the University no buildings where the graduation proceedings take place, that is to say, where degrees are granted ?—We have a hall in the library (the only hall now which is not crossed and recrossed by erections in order to contain books), where the rector when he comes down gives his address, and where the ceremonial of graduation takes place. It is very inconvenient and inadequate for the purpose, but it is the only place that we have.

9673. Could the University with its present staff of professors undertake to give instruction in Dundee, supposing the scheme to which you have alluded were carried into effect ?—I think not.

9674. It would be necessary to increase the staff ?—Yes.

9675. Is any portion of the small surplus income which you possess applied from time to time in purchasing additional scientific apparatus ?—No, not beyond the grants that have been given to the class of natural philosophy and chemistry annually. We give in the case of the Professor of Natural Philosophy a grant of 52*l.* a year, and the same sum in the case of the class of chemistry; and the Professor of Physiology and Anatomy is entitled also to a small sum.

9676. (*Dr. Sharpey.*) And that goes merely towards apparatus and materials, not for assistants ?—No, not for teaching assistants.

9677. (*Chairman.*) Those sums are charged, are they not, upon the income of the University which is derived from the sources which you have already explained to us ?—Yes.

9678. Can you give us any similar information about the income of the colleges; have they any endowments ?—I could give general information, but not very specific details. I can give it as to my own college. The revenue in our college is about 1,150*l.* a year, including bursary moneys, and without deduction of public burdens, &c.

9679. Does that include the fees from students ?—No, I am now talking of revenue from property. I may mention that the property is of two kinds, land and tithes. The colleges were originally endowed entirely with tithes, or, as we call them in Scotland, teinds. In our college at least the land is of comparatively recent acquisition. When the archbishops founded the colleges, they applied the tithes of certain parishes in their own gift for their benefit, and sent curates or vicars to do the duty in the parishes. These revenues have remained subject to the usual deductions which tithes are subject to, in the hands of any titheholder; that is to say, the parish minister's stipend may be increased out of the unexhausted teinds, and in that way even our small college alone has suffered a diminution of between 500*l.* and 600*l.* a year. The question was litigated last century. The colleges maintained that the tithes were in their hands, not as titulars but as beneficiaries, but the court found that they were in the hands of the colleges, simply as in the hands of any other titulars, and of course the minister of the parish was entitled to the augmentation of his living, according to the Scotch law. Every successive 20 years he may apply, and it remains with the court to judge whether application is well founded or not. If the augmentation is granted it is so much money out of the college revenues, and we are liable to further deductions in future.

9680. Do you derive any assistance from the Government, except in the form which you have already explained to us, namely, keeping your buildings in repair ?—There are certain small grants voted annually for the benefit of the several Chairs, and the present buildings of the United College were erected by Government money. The old buildings had got into the state of dilapidation which I have explained, and, owing very much to the energy of the late Sir Hugh Lyon Playfair, who was provost of the city for many years, together with the assistance of Mr. Ellice, who has been our member for St. Andrews for 30 years, they got from the Government of that time a sum of money to erect the present United College.

9681. Are they buildings that belong to both the colleges, both to St. Mary's College and the United College ?—No, only to the latter.

9682. And the present buildings are to a considerable extent new ?—Yes, the buildings of the United College I may say are entirely new. The buildings of St. Mary's College again are mainly restored buildings. The fabric is partly at least as old as the foundation of the college.

9683. Can you state to us whether you consider the University to require additional apparatus and appliances for teaching ?—Yes, undoubtedly.

9684. And you have no funds from which you can supply them yourself ?—We have no funds adequate for such a purpose. It is possible that our University funds may expand, and of course this, as well as any other University object, might be so far a claim upon those funds, but there is no such prospect as far as we can see.

9685. You have made no direct application, have you, to the Government for assistance, except with regard to the library ?—No.

9686. You have never asked them for assistance in enabling you to provide the appliances requisite for teaching in other respects ?—No; our conclusion naturally was that when the late Universities' Commission failed to find funds for such an object, we were not likely to succeed as a University.

9687. (*Dr. Sharpey.*) Speaking of the museum, I presume that the specimens are merely such as persons have presented casually to the museum ?—Entirely so, I believe.

9688. Was it ever in contemplation to apply to any public sources for specimens, such as the Geological Survey of Scotland and England, or for duplicates from the British Museum ?—Not so far as I am aware.

Rev. J. Tulloch, D.D.

1 March 1872

9689. There are bursaries, are there not, in St. Andrews ?—Yes, there are a good many bursaries.

9690. But none of them are applicable to scientific study ?—None of them specially. Of course, so far as science enters into the curriculum for arts, a student may take science particularly as his department of study, and may hold a bursary, but there are none of them given specially for scientific attainments.

9691. Might not two or three of those bursaries be consolidated, so as to make a payment for scientific assistants. For example, in the class of natural philosophy, or of chemistry, might not a young man, by means of such a payment, be maintained there for a time, giving assistance and being himself profited by a continued residence in St. Andrews, working at some scientific subject ?—That is possible, but we have no power to do it.

9692. Supposing power were obtained, would it be otherwise practicable, do you think ?—The great difficulty about such a scheme, so far as it occurs to me, would be the just claims of the other departments of study; the classical Professors would not be disposed to allow anything that would interfere with the prosperity of their side of the University teaching. That would be a difficulty I should think.

9693. And some of those bursaries, I suppose, are private foundations ?—Yes, almost all the most valuable of them are private. There are bursaries that are termed foundation bursaries, or college bursaries, but they are of comparatively small value.

9694. The Commission may infer from that that you see no other source for the payment of assistants except aid from the State ?—I know of no other source, except from some liberal private individual.

9695. Are there many of your students who afterwards become teachers in parish schools, or borough schools, or academies in Scotland ?—A large number. Some come to England and go into private academies. I have noticed of late a good many students who, in former days, might have gone into the Church, find their way into such academies or schools. There are many more difficulties about the Church now than there used to be, and some of my own students, even after years of study for the Church, have become teachers of classics and sometimes of science.

9696. Are any considerable number of them engaged in teaching science ?—I should say that a good many have devoted themselves specially to science. I may mention Dr. Lyon Playfair, so well known by his scientific and educational labours, Dr. Page, well known as a geologist, and one who was a fellow student of my own, Dr. Lindsay of Dollar, who acquired quite a reputation for training men to pass the Civil Service examinations in mathematics, or natural philosophy; he was a man of great energy and ability, and was trained mainly at St. Andrews, with a year or so at Edinburgh; he has devoted himself to the object of training men for the public services at Dollar, entirely in science.

9697. Do you think that the University of St. Andrews could afford the means of giving practical instruction in science to such young teachers, as, for example, in natural philosophy and chemistry, as distinguished from mere attendance on lectures ?—Yes, I think so.

9698. It has been shown before the Commission that in the teaching of science there is this great defect generally in schools in England, that the teachers themselves have often very little real acquaintance with the subject, but merely a knowledge derived from books, and probably you are aware that means have been taken in London, through the Science and Art Department at South Kensington, for giving them opportunities of obtaining practical instruction in chemistry and also in zoology and animal physiology; can you form any opinion whether the means could be afforded of doing that at St. Andrews, as a centre to which young men could resort for the purpose of receiving such instruction ?—We might furnish means for such a purpose, or at least we have ample opportunities, if we have not at present ample means of doing so.

9699. Supposing you had a sufficient extension of your practical rooms, with adequate apparatus and additional assistants, do you think you could accomplish that object ?—I think so; I think we might do a very useful and large work in that way.

9700. In London the expense was defrayed by Government money through the Science and Art Department. The assistant teachers that were engaged for the purpose received a payment, and there was a small allowance given for maintenance to the teachers who came up for instruction; do you think that something of the same sort might, with advantage, be adopted at St. Andrews ?—I have no doubt of it. I have had a great deal to do with schoolmasters in Scotland, being Secretary for the Examining Board of Schoolmasters in our University, and also being connected with the Dick bequest, which in the north of Scotland has been of great importance in elevating the standard of school teachers. I should say that there is nothing that the teachers need more than some real and living knowledge of scientific facts. They know the subject from books, but everybody who has tried to learn science from books knows how very imperfect such a knowledge is, and it appears to me that very useful work might be done in the way that you have indicated.

9701. You mean through your present staff of professors, aided by competent assistants ?—Yes, aided by room, by apparatus, and by the means of working.

9702. Who conduct the examination in arts ?—The examination in arts is conducted by the professors assisted by a paid examiner. That was one of the improvements arising out of the late Universities' Commission. There is a paid examiner for the scientific department, and a paid examiner for the mental science department, and a paid examiner for the classical department.

9703. I think you mentioned that, in case of an affiliated institution being established in Dundee, you do not contemplate doing the duties there through the existing professors of St. Andrews, but by appointing additional professors ? -Yes, either appointing assistants or additional professors.

9704. Would it be practicable for a man who has classes to teach at St. Andrews to be sent to Dundee, and give efficient instruction there ?—I hardly think that practicable. It might be practicable for a very vigorous young man to give evening instruction in Dundee by means of the communication that will by-and-by exist; but it would require a man in full health, and of great energy, and we could not expect every professor to undertake work of such a kind, nor could we lay it upon him. [*See* APPENDIX V.]

WILLIAM SWAN, Esq., LL.D., examined.

W. Swan, Esq., LL.D.

9705. (*Chairman.*) You are Professor of Natural Philosophy in the University of St. Andrews ?—I am.

9706. Will you be so good as to describe to the Commission the duties which attach to your Chair ?—My duties are lecturing to my students and examining them. I have seven lectures a week, and during the session, besides oral examinations, I have generally six examinations in writing. I also prescribe home exercises, problems usually once a week, and I have those problems and papers of various kinds to examine.

9707. What are subjects which you consider to be comprised under the head of natural philosophy ?—The subjects of the lectures are those which Principal Tulloch has mentioned, and which are taken from the St. Andrews Calendar; they are those usually included in a course of natural philosophy.

W. Swan, Esq., LL.D.

1 March 1872.

9708. Have you any assistance in the delivery of those lectures?—I have no assistance.

9709. Are those subjects, as a rule, treated mathematically?—On Tuesdays and Thursdays, four hours a week, I give lectures on applied mathematics, with occasional experiments, where they may be necessary. On Mondays, Wednesdays, and Fridays, the remaining three hours at my disposal I devote to lectures on experimental physics. I do not exclude mathematics on these days, and the lectures are as fully illustrated by experiments as my means enable me. I may say that they are very fully illustrated by experiments.

9710. Are your classes attended both by the junior and the senior students?—There is no rule laid down at St. Andrews as to the order in which the classes in the arts curriculum may be taken. It is recommended that my class should be attended in the fourth year; but in point of fact students of all years come. I should say seldom earlier than the second year. My class is mainly made up of fourth year and third year students.

9711. Is it customary for students to remain four years at St. Andrews?—They must remain four years to take a degree in arts, unless they avail themselves of the provision made by the late University Commission, by which they can get a degree after three years, provided they undergo on entering college an examination in Latin and Greek. So that those students only attend for three years: others must attend for four years.

9712. What is the most advanced age at which you have any students?—It is difficult to say. There are exceptional cases of pretty old men attending my class.

9713. What is the average age of your students?—I have a student about 30 years of age, a schoolmaster, in my class now, but such are exceptional cases. It must be borne in mind that the Scotch University system affords facilities for men of the humbler classes coming to college, which are scarcely known in England, therefore many men come up to college who are pretty well advanced in life. I had an excellent student of this kind two or three years ago. Another, was a stonemason, who worked all the summer and came up to college for the six months' session, and I should guess his age to have been about 30 at the time he was attending my class. One might say that 20 is about the limit, with occasional notable exceptions in excess. My students are generally under 20 rather than above it.

9714. Have you a commodious room for lecturing in?—The lecture room I should say is excellent, it is amply sufficient for present purposes. If our better connexion with Dundee brought a great many more students it is possible that it might become too small, but at present it is amply sufficient. It is well fitted with gas and water fittings. I have no complaint to make with regard to the lecture room.

9715. Have you also a room for apparatus?—I have a room for apparatus, that is quite insufficient for the apparatus which I possess and for working purposes. If I may be allowed to go into detail, I may say that the free floor space between the apparatus cases measures 28 feet by only 10. Now 10 feet of width makes but a very narrow room, and the floor space is already encumbered. There must be a working table: and large pieces of apparatus, such as Bianchi's air pump, Winter's electrical machine, and other things must be accommodated on the floor, so that I have very little room for apparatus, and that room, of course, every year is becoming more crowded. By fitting up cases in a passage leading to the lecture room, and by placing shelves under the students' seats, I have utilized every available inch of room in the present building.

9716. Are your rooms in one of the colleges belonging to the University?—My rooms are in the United College. Perhaps in explanation of the term United College, I may say that at one time there were three colleges in St. Andrews, St. Salvator's, St. Leonard's, and St. Mary's, but in 1747, by Act of Parliament, two of those colleges, St. Salvator's and St. Leonard's, were united together, and for shortness sake we call it the United College, the strict title being the United College of St. Salvator and St. Leonard.

9717. Then the United College does not include St. Mary's?—It does not. St. Mary's is simply a Divinity College now.

9718. Would it be possible to give you additional accommodation for apparatus in the present buildings?—Not in the present buildings, but there is ample available space behind the present buildings on which additional rooms could be erected; and on looking at it pretty carefully, I think I am safe in saying there is a space of 62 feet by 60, on which a building of three storeys could be erected quite conveniently situated both for my colleague, Professor Heddle's purposes, and my own, of which three rooms at one end would be conveniently situated in connexion with my class-room and apparatus room, and the other three at the other end would be equally suitable for Professor Heddle's purposes. I state that entirely upon my own responsibility. I do not know what Dr. Heddle may say to it. When I speak of so many apartments being erected, I am thinking of the possibility of a physical laboratory for purposes of instruction being provided in connexion with my chair, and also a sufficient suite of apartments for Dr. Heddle's purposes. But not by the University funds. We should need a grant from the Government. Dr. Heddle has no practical laboratory at present, so that I think all that accommodation would be required in the event of a physical laboratory being provided as well as additional room for the increasing collection of apparatus, and also for Dr. Heddle's use.

9719. I think we understand that the present buildings were erected by the Government some years ago?—A good many years ago. One portion about 1831, and the rest about 1845, I think.

9720. Could you from memory state to us the funds that belong to your Chair?—I may state generally that the funds, as estimated by the University Commission in 1861, were 444*l.* 18*s.* There was one question that was put to Professor Tulloch regarding the eligibility of the college and University funds for such purposes as this Commission contemplate, and that is one reason perhaps why I should say a few words more in explanation of those funds. Those emoluments, amounting to 444*l.* 18*s.*, are made up as follows: first, there is the salary of 80*l.* by Act of Parliament of George the Second; that I must get so long as there is any money to give it. In like manner my colleagues get such salaries as are fixed by the Act; but after the salaries are paid away and certain sums have been set apart for purposes enjoined by the recent University Commissioners, there is a surplus of college revenue, of which my share, as estimated by the Commission, is 129*l.* 18*s.*, but that is over-estimated considerably. After those payments are made to the several professors of the college, the whole of the funds of the college are exhausted; we have no power in any way to alienate to any other purpose those moneys. The salaries were fixed by Act of Parliament, and the share of surplus college revenues I can claim, and my colleagues can claim, and when these payments are made there is not a farthing of money over. The appropriation of the whole college revenues is thus determined either by Act of Parliament or by the Ordinances of the Commissioners, ratified by the Queen in Council, and therefore cannot be altered excepting by Act of Parliament, so that there is not a farthing of our college revenues that can be applied in any other way by us than it is at present. The Natural Philosophy Chair may be taken as a typical case, and as illustrative of the position of the Chairs generally.

9721. (*Professor Stokes.*) May the statutes be altered by application to the Queen in Council?—I suppose they may.

9722. Therefore it does not require an Act of Parliament?—I believe you are right; but, practically, to effect any important financial changes an Act of Parliament would be required. Then, to return to the enumeration of funds belonging to my chair, there is a parliamentary vote amounting to 150*l*., and my students' fees as estimated by the Commission at 85*l*., which make up the whole sum of 444*l*. 18*s*. I may state that the average amount of fees has been somewhat less than that. For the last 10 years they have amounted to 81*l*. 8*s*., and the average attendance upon my class has been 28 students.

9723. (*Chairman.*) Is 150*l*., the salary from the Government, fixed by Act of Parliament?—It is an annual vote, the amount having been fixed by the Commissioners under the Universities Act of 1858.

9724. Not a charge upon the consolidated fund?—My impression is that it is an annual vote.

9725. Besides your own salary have you any assistance from the University funds for apparatus, or other purposes?—The University allows me a grant of 52*l*. 10*s*. for class expenses, and I am allowed out of that to make a small payment to an assistant. I pay my assistant 12*l*., but of course any assistant that I can get for that money cannot be intrusted with anything like the preparation of experiments. He is not an educated assistant in short.

9726. The remainder of this 50 guineas is applied, I presume, in maintaining the apparatus?—In repairing and purchasing. Almost exclusively in purchasing apparatus.

9727. Have you no other funds available for those purposes?—No other means whatever, except what I choose to give myself, and I am generally out of pocket every year both for apparatus and materials.

9728. (*Dr. Sharpey.*) What is the fee paid by the students?—Three guineas for the session.

9729. (*Chairman.*) The Scotch Universities' Act does not, I believe, provide you with any teaching assistants?—No. In St. Andrews no teaching assistants were provided. The Universities' Act made distinct provision for teaching assistants for the professors in the various Scotch Universities, and such were generally provided in Aberdeen, in Glasgow, and in Edinburgh, but none were provided for St. Andrews.

9730. Was St. Andrews considered to be on a smaller scale than the other universities?—I believe that was the ostensible reason, but there was another reason which I have no doubt operated. The sum of money put at the disposal of the Commissioners was extremely limited. I think it was not above 12,000*l*. a year altogether, for the whole of the Scotch Universities. But at all events I can say that it was extremely limited, and when, after the publication of their financial ordinances, we asked for further assistance they told us that they had no more money to give us, that their funds were exhausted. I think that had as much to do with it as any other thing. I have thought it of importance to direct the attention of this Commission, in case by any chance it might not be otherwise directed to the fact, that while the late Scotch Universities' Act made provision for teaching assistants to the University Chairs generally, there was no special provision whatever made of grants out of the public money for the purposes of teaching experimental science and natural history. It seems to me that this is a fact of some importance.

9731. Does that apply generally, or only to the University of St. Andrews?—It applies quite generally. In the University of Aberdeen indeed certain small grants for class expenses were made out of moneys got by a vote of Parliament, but those moneys had been previously obtained. They were not obtained through the instrumentality of the University Commission: and the point that I want to bring out is this, that there was no provision made in the Universities' Act for the commissioners making recommendations that money should be voted by Parliament for the support specially of classes teaching natural science, and therefore if this Commission should issue any recommendations for grants, I think the case is strengthened by the fact that nothing has been done in that direction through the recent Universities' Act.

9732. Was any provision made in the Universities' Act for assistance in teaching physical science?—Yes, there were teachers appointed to classes of physical science, as well as to the other University classes, but these were merely teaching assistants. The point which I wish to bring out is that there was no assistance whatever provided by means of public moneys obtained through the Act for purchasing apparatus or providing curators of apparatus or experimental assistants; and I think it is a matter of some importance that that should be known.

9733. Was any distinction made in the Act in other respects between the case of St. Andrews and the other Scotch Universities?—In the Universities of Edinburgh and Glasgow the Commissioners enjoined by ordinance the payment of sums annually, but out of previously existing University funds, for class expenses, in favour of the Chairs of Natural Science, those class expenses including the purchase of apparatus; but in St. Andrews such grants were not enjoined, but merely permitted.

9734. Was there any reason for that distinction?—I think it may have been this, that the Commissioners were aware that at the time the University funds were little more than able to meet the demands upon them. I believe that they were unwilling to compel the University to pay a fixed sum every year, when really money was a little scarce. But the University funds are somewhat better now than they were then.

9735. Then practically the money always has been provided by the University?—Yes, I have no complaint to make in that respect.

9736. You have much good apparatus, but it is insufficient for what is properly required for the illustration of your lectures?—Yes, there is a very considerable collection of good apparatus, including many valuable articles, but still the grant of 52*l*. 10*s*., more especially after deducting 12*l*. for an assistant, is quite inadequate to defray the annual expenses of my class in the purchase of apparatus.

9737. Do you feel the want of an assistant of a different kind from that which you are enabled to provide under the present arrangements?—I do very much indeed. Indeed, I am obliged every day that I give an experimental lecture to work for a great many hours, never less than four hours, doing a great deal of work which an assistant ought to do. Then on the other alternate days, by anticipation, I am also obliged to work in preparing experiments, so that a great deal of time is occupied in doing common work, which an assistant might do. Even our present stock of apparatus is valuable, and will every year become more so; and in the event of increased grants, we may expect to have a very valuable stock of apparatus in a few years. It is extremely desirable that some curator of such a collection of apparatus should be provided able to take care of it. Such an assistant as I have at 12*l*. a year, although he is an extremely intelligent and perfectly honest man, has not knowledge enough to be entrusted with such a collection. It would need a man specially educated to take charge of such a collection.

9738. (*Professor Stokes.*) In the discharge of the duties of your professorship your time may be conceived to be taken up partly in preparing for lectures, partly in giving the actual lectures, and partly I presume in looking over examination papers and work of that kind?—Yes.

9739. Is the expenditure of time on that third head considerable?—It is, but the first is the greatest certainly. I have six sets of examination papers during the session to examine, besides the papers at the end of the year connected with graduation, and I have also the students' weekly problems to examine, but I never made an exact comparison of the times devoted to these different things. I am, however, certain of this, that the time occupied in the mere preparation of experiments for my class, taking it

W. Swan, Esq., LL.D.

1 March 1872.

all through the session, must be very much greater than that devoted to the examination of papers and exercises.

9740. (*Chairman.*) Have you anything that can properly be described as a physical laboratory at present?—There is no physical laboratory at present.

9741. Do you think that such a laboratory is required for the proper discharge of your functions?—I think it is. I think the wonder is that we have been so long without having physical laboratories in connexion with Chairs of Natural Philosophy, and I conceive that now no establishment for teaching natural philosophy can be regarded as complete without a physical laboratory.

9742. I understand you to say that there is space for such laboratory, but not the funds for the erection of it or for providing apparatus?—Quite so. Besides the apparatus intended specially for my lectures, many other things would be required. I think we should be obliged to get many things in duplicate for teaching in the laboratory, and additional apparatus over and above what may be wanted for the purposes of my lectures.

9743. What are your views as to the proposal to establish affiliated institutions in Dundee?—I should like exceedingly that the University of St. Andrews should be made available for teaching science and other subjects in Dundee, and I trust that the erection of the Tay bridge, by facilitating communication between St. Andrews and Dundee, will go a great way to help that; but it seems to me that if lectures are to be given in Dundee it must be done by teachers appointed in connexion with the University, and not by the present University professors. I find that at present I have quite enough to do with my work at St. Andrews.

9744. At present have you any students from Dundee?—I have had, but comparatively rarely, very rarely indeed, I may say, a student coming from Dundee daily and returning in the evening. But every year I have had students from Dundee who have resided at St. Andrews, and some of my best students have come from there.

9745. Have you any expectation that when the communication is better than it is at present possibly the people of Dundee may be satisfied to come to St. Andrews for their teaching?—It will satisfy one want. The sons of the wealthier or middle classes, of course, can come to St. Andrews; but still I feel that clerks in offices and artisans cannot be provided for in that way. It would be necessary for them to have lectures in the evening in Dundee.

9746. (*Professor Stokes.*) What would the distance be when the bridge is erected?—I think about 12 or 13 miles. A ride of about half an hour or 40 minutes. I have not seen the plans of the proposed line of rails.

9747. (*Chairman.*) Still, even when that communication is improved, you probably expect that the whole of the objects that the Dundee people have in view will not be accomplished without the establishment of some affilated institutions in Dundee itself?—I think so, but I must say that I have no faith in our existing staff of professors being made available in Dundee. I think we may do more good at St. Andrews after the bridge is erected, but I do not think we can be expected to teach in Dundee.

9748. Are there any other points on which you wish to make additions to your evidence?—There is just one which I think has scarcely been taken up, although it has been mentioned, and that is the fact that whilst at other Universities grants for class expenses have been enjoined by the Commissioners, at St. Andrews such grants are merely permitted, and I do not think it is desirable that such grants should be put in such a precarious position as that. I may say that in the improved state of the University funds, I do not think that a grant of 100*l.* a year each would be too much for my class, and for Dr. Heddle's. I think that the University funds might stand so large a grant as that.

9749. Have you ever made any application to the University authorities for further assistance?—I have not done so.

9750. Have you reason to believe that the University funds would now admit of the addition that you would think desirable?—I think so. Of course a still greater addition would be needed in the event of a physical laboratory being erected, but for the purposes of carrying on my class, as it is carried on now, I think at least 100*l.* is necessary, and that it might be provided.

9751. Probably there are other professors who also might wish for some further assistance from the University funds?—Yes, that is true.

9752. (*Professor Stokes.*) If science teaching were to be given at Dundee, equally efficiently with that which can be given at St. Andrews, would it not be necessary to provide not merely teachers, but also laboratories and buildings of that kind at Dundee?—It certainly would.

9753. In fact to establish what would be equivalent to another University?—That is putting it very strongly. Another branch of the University I should say complete in itself.

9754. And would it not be necessary that the students attending it should have, if not their whole time, a good part of their time free during the day, and should not merely come to an evening lecture after they have been wearied with the day's work?—Yes, it certainly would be desirable for efficient work that they should.

9755. So that what could be done in the way of evening lectures would be only a sort of makeshift, in default of something better?—I should say so. I think that the sort of instruction likely to be got there, however good of its kind, would certainly require, in order to be effectual, that those who came for it had time to study at home, and therefore I do not expect that it would come up to the quality of proper University instruction.

9756. And if they had their time to study at home during the day, might they not almost as well go to St. Andrews?—I think so; but such things are as yet merely on trial. No doubt good may be got by artizans attending evening lectures, such as are contemplated; but how much good they can get is not so easy to judge. I do not think it is to be put in comparison with the training which a student ought to get, and would get, by attending one of the Universities, and devoting his whole time to the work of the University.

9757. (*Chairman.*) Do you think it is possible and that it might be advantageous to remove certain departments of the University of St. Andrews to Dundee?—I am scarcely prepared to answer that question; I think there would be difficulties connected with it. One difficulty I may just observe is this,—my class, for example, is a class in the curriculum of arts; the existing students who come to St. Andrews do not all come from Dundee, only a section of them, and moreover they have other classes to attend, and it would be a serious hardship to oblige a man to go for some of his classes to St. Andrews, and for others to Dundee. Even with the Tay Bridge I am afraid that that would be impracticable.

9758. Is there any other point upon which you wish to make any remark to the Commission?—There is one other point. I have stated in the précis of my evidence that for the efficient working of the Chair 80*l.* for an assistant, and 100*l.* annually for apparatus, would be required. I should wish to say that so large a grant would be quite beyond the means of the University; but as I stated before, I think that 100*l.* a year altogether would be within the means of the University, always assuming that the existing revenues be not diminished through the large claim for unexhausted teinds to which Principal Tulloch referred, or through any other cause. [*See* APPENDIX V.]

The witness withdrew.

M. Forster Heddle, Esq., M.D., examined.

M. F. Heddle, Esq., M.D.

1 March 1872.

9759. (*Chairman.*) You are Professor of Chemistry in the University of St. Andrews ?—I am.

9760. You can give the Commission information on certain points connected with your professorship; and, first of all, will you have the goodness to state the amount of the professor's salary ?—The Professor of Chemistry has no share of the ordinary funds of the United College. The Chair was instituted by a private mortification or will, and the total sum derived from that source is 90*l.* a year.

9761. Is that the only salary that the professor has ?—There is a Government grant of 125*l.* a year also; the professor likewise has the class fees, which may be stated at about 70*l.* or 80*l.* a year, but on account of the insufficiency of the grant for experimental illustration, the professor as yet has always had to expend that and a larger sum still out of his own pocket. Except in one year I never put a class fee into my pocket.

9762. How many students have you attending your lectures ?—At present about 30.

9763. Is it necessary for a degree that students should attend your lectures ?—It now is necessary for a degree. I may state in this connexion that chemistry was in the curriculum of arts in the University of St. Andrews at the time I joined the college, or immediately before, but it was struck out of it indirectly by an ordinance of the University Commissioners. It was not in the curriculum of arts in any other Scotch University, and the Commissioners did not place it in the curriculum of arts. Their ordinances were intended to apply to the Scottish Universities generally, and so by their not placing it in the curriculum of the Universities, it indirectly came to be struck out of that of St. Andrews; it was not immediately attempted to be reponed because it appeared to my colleagues that it would be a hardship to their students that they should be called upon to attend an extra class, when this was not demanded in Edinburgh and elsewhere; and that possibly the number of students at St. Andrews might so be diminished. However, it proved to be no hardship, because all the better students voluntarily attended the class of chemistry, and it has now been reponed, or rather the new regulations will come into effect next year; I may state that the average number of students attending the class before it was struck out was upwards of 30, upon its being struck out they immediately fell to 12; but they have gradually increased again, so that now they stand at very nearly the original 30.

9764. Is your class usually attended by students in their last year ?—Yes, but it is not enjoined in any way. I may state that I have very great difficulty indeed in teaching what may be considered to be the whole of my subject, on account of chemistry not being taught in the schools. I am kept back by having to teach the very elements of the subject.

9765. What information can you give the Commission as to your class-rooms, and any other rooms that may be attached to your Chair ? — The class room is sufficient, and it is excellently fitted; and the apparatus room is sufficient, but not well fitted. There is, however, the anomaly that there is no chemical laboratory whatever; and accordingly the professor has to prepare his experiments before his lecture, in his class-room, and then he has to get the class-room in every way in order. Experimental chemical preparation is dirty work, and it entails a very considerable amount of cleaning, and the apparatus is constantly being moved and removed. Then, again, there is no class-room for teaching practical chemistry. I have attempted to carry it on in my ordinary lecture room; this entails a great amount of carrying about of the apparatus, so that I have had very unwillingly to discontinue the teaching of practical chemistry.

9766. Are there any rooms in the building that could be applied for the purpose ?—None.

9767. What funds have you for providing apparatus and chemicals ?—There is an annual grant from the University of 52*l.* 10*s.* for all expenses, the expenses of apparatus, chemicals, and assistants. Upon getting this Chair, I attempted to get an assistant, but I found that I could not get one for a larger sum than the total of that grant; so that I have never had any assistant at all, except that sometimes a senior student has been willing to aid me a little for his own information, but I found this plan to entail so much teaching that it even I have discontinued.

9768. Have you ever made application for an increase of those funds ?—Never. I have stated frequently that they are insufficient; but in the present circumstances of the University I have never made an application.

9769. What is your opinion as to the point mentioned by Professor Swan ? Do you think that the University would be able to spare you a little more money for the purpose ? — In the present circumstances of the University, I doubt it. I think that the application of all their surplus to the library is so legitimate, and so much called for, that until the new building is put up I would not wish it; but when that building is put up I think that the sum allocated to us is much too small; after it is put up they could certainly afford more, but in the present circumstances I would not press it; and, besides there is the other indefinite charge, which Principal Tulloch referred to, which is hanging over us.

9770. Do you consider that the demand for teaching in your department of science is increasing in the district ?—I do. I have been requested by many of the large towns around to lecture, and in some cases I have done so, but on account of the great want of apparatus in those localities, I have had to carry about with me my own apparatus, and very unwillingly I have been obliged generally to refuse. I have lately had an exceedingly urgent call from Dundee, but, under such circumstances as I have mentioned, it was quite impossible to meet their wishes.

9771. Have they evinced any disposition to provide apparatus in the towns ?—Not except in connexion with the so-called Dundee scheme. In one case in Cupar they have, in what is called the Duncan Institute, somewhere about 150*l.* a year, and they not only offered to supply apparatus, but they urged me to purchase apparatus for them,—I am lecturing there at present.

9772. The income attached to your Chair was estimated, was it not, by the Commissioner at somewhat more than it has actually produced ?—Yes, through an error of the clerk of the College.

9773. Is the amount provided for apparatus and chemicals in the University of St. Andrews, much less than in other Scotch Universities ?—Very much less. In Edinburgh 300*l.* is by an ordinance of the Commissioners set aside for that purpose; and it also costs the professor a very much larger sum than that; and in Aberdeen, and in Glasgow, the sums are 270*l.* and 260*l.*, for the same purposes.

9774. And are those sums found to be insufficient?—I cannot exactly say that they are found to be insufficient. The professor chooses to spend a very great deal more, but whether he might not do it upon that is a question which I cannot answer.

9775. Still it is practicable to spend a much larger sum with advantage in conducting this course of instruction ?—Yes. Dr. Lyon Playfair spent very nearly 1,000*l.* a year.

9776. Is your apparatus in many respects very much behind what is required by you ?—Yes. I could not conduct a class unless I had a large quantity of apparatus belonging to myself. All the more delicate apparatus is my own property. I have also had, at my own cost, a cost of over 200*l.*, to fit up a workshop for the manufacture of apparatus.

9777. Is your time so fully occupied with preparations for your class as to leave none for original research ?—None whatever, or almost none, during the time of the session.

M. F. Heddle, Esq., M.D.

1 March 1872.

9778. How long does the session last?—Very nearly six months.

9779. Is your time free to do what you like during the rest of the year?—Yes, during the rest of the year it is, which time might I think be economised.

9780. Can you state to the Commission what you think is absolutely needed in order for the proper discharge of your duties?—In present circumstances I think an assistant at a salary of not less than 80*l.* to be absolutely necessary; and it would require a sum of from 100*l.* to 120*l.* for the purposes of apparatus and chemicals, and waste of materials, that being the amount of the sum which I have voluntarily spent out of my own pocket, or made up out of my own pocket, in order to keep the class in efficient working. Any increase in class attendance will of necessity call for a larger outlay.

9781. Have you formed any opinion as to the proposed establishment of affiliated institutions in Dundee?—I may mention that in the scheme which has been brought forward, chiefly I believe by Principal Shairp, one part of that scheme is that I personally should go over and teach in Dundee; I am perfectly willing to do so if it is practicable; I need not say that a professor who has only 200*l.* a year must be very willing indeed to increase his salary, but I think that there are grave difficulties in the scheme as at present proposed; I understand that the scheme is that in order that I might teach there, I should be relieved of part of my duties in St. Andrews, and that I should only teach in St. Andrews two or three days a week, and go over and teach in Dundee on the other days. It seems to me that if chemistry has been considered of such importance as to place it in the curriculum of arts, it is a somewhat anomalous proceeding immediately to cut it down to two classes two days per week instead of five. This brings us to consider whether the professors are to teach, or are we to teach by professional assistants. If it is to be worked in harmony with, or in connexion with the University of St. Andrews, I think it might be worked if professional assistants were to teach, but I cannot see how you can expect a professor of St. Andrews to teach at Dundee five days a week; he would have to absent himself from his home altogether, and I doubt if you would get up funds that would induce a professor so to absent himself from home. Then again if the scheme is chiefly for the benefit of Dundee, I think it would be very much better to institute a school of science in Dundee or to carry the scientific professors bodily over to Dundee, and have only one set of class-rooms and one set of apparatus, instead of having to supply two. But, you must consider, if you are going to have a school of science in Dundee separate from St. Andrews, whether you are not going to do harm to St. Andrews instead of good. It would certainly tend to draw away from St. Andrews all the students who at present come from Dundee, and all the students who might come when we are going to get those increased facilities which have been mentioned; so that while I admit that Dundee is a much better locality for a school of science or for scientific instruction, if you are to look at the number of students and the good that it will do generally, I cannot see that the present scheme is feasible. I am perfectly willing to do all I can to work hard, but I cannot see the way in which it is to be feasible, even with any amount of surplus energy that some professors may have. For myself at present my time is so fully occupied that I can hardly find time to correct my class exercises.

9782. Do you consider that there would be very great difficulties in removing some departments to Dundee and leaving others at St. Andrews?—No, I do not see those difficulties. I think that the whole of the scientific students might attend at Dundee. I have not considered the subject sufficiently, but I was a little staggered at my colleague saying that there would be difficulties.

9783. (*Professor Stokes.*) If they had to attend classes in Dundee, and classes in St. Andrews on the same day, would there not be a difficulty?—Then there would be a difficulty certainly.

9784. (*Chairman.*) Do you think it would be better if any institution is formed at Dundee for teaching science, that it should in some way or other be connected with St. Andrews, rather than be independent?—Yes, I do. I would not say that we have too many Universities in Scotland, but I think we have quite enough, and this is a kind of starting a new University, and one which would be a little nearer to Aberdeen. I think it might be a school of science affiliated to St. Andrews, and that perhaps the scientific professors might teach solely there.

9785. Is there any other information which you would wish to give to the Commission?—In the first place I may state that the fee at St. Andrews is smaller than that at other Scotch Universities, and I think it is well worthy the consideration of the University of St. Andrews itself, whether it would not be well to make the fee the same. The fee for chemistry in Edinburgh is four guineas, and in Glasgow also, and I am not sure that it is not the same in Aberdeen. I consider that if the fee for attending the ordinary classes is three guineas, certainly the fee for attending the experimental classes should be four guineas. There is no getting quit of this extra expense, and if the students get the benefit of it, why should the professor pay it out of his own pocket instead of the students paying it?

9786. That rests with the University authorities, does it not?—It must receive the sanction of the University court. Then again I would make a remark with regard to the point as to what the Commission did as to the assistants. It was perhaps this, that the revenue of St. Andrews was not known at the time that the Commission were sitting, whereas the revenue of the other Universities was pretty well known; and not only was the revenue of St. Andrews not known, but we were getting a very large increase to our capital at the time through the very large number of medical men who were rushing to St. Andrews; and that may have been the reason why the Commissioners did not absolutely do more than enjoin that increased sums should be laid out for class expenses. Then I should wish to say with regard to my colleague's idea of increased accommodation, that not only might those class-rooms which he has spoken of be very easily put up, but it would not be at a very great cost, for this reason, that there already has been a stair provided for something of the kind, and there would be only the expense of class rooms, without the expense of lobbies and stairs, or anything of that kind, so that it would be a wing applied to a place where there is a certain amount of provision already existing. Then, speaking of the little time which a professor has, I may mention that in the year I have 8 to 12 written examinations, and the papers which are given in are so very long, in many cases, that it cuts up any little leisure that a professor may have at home; in fact it is in most cases with me night work.

9787. Is the revenue of the University of St. Andrews increasing, because you stated that its financial position had improved since the Commissioners examined into the matter?—Its financial position improved as regarded capital, because we got a large amount of money from graduation fees, but what I referred to was funded capital, and now its revenue is, if anything, diminishing. We are now only permitted to give 10 medical degrees in the year, and these to medical men over 40 years of age; and there are certain other restrictions. Now the number of medical men over 40 years of age who have not got degrees is diminishing every year, on account of the working of the Medical Act, so that the chances of revenue thence accruing have decreased, and I see very clearly that ultimately it will not only decrease but entirely fall off. With regard to my own chair it may seem somewhat anomalous that any Professor should sit at such a salary as 200*l.* a year, but the emoluments of that Chair were derived almost totally from the sums paid to the medical examiners, one of whom was the Pro-

M. F. Heddle, Esq., M.D.

1 March 1872.

fessor of Chemistry, and the revenue from that source the very year before I got the appointment was 500*l.* The Commissioners not only restricted us to 10 degrees, but they passed an Ordinance by which the Professorial examiners were not to get one penny for their work in future, so that this whole 500*l.* was struck out of the Professor of Chemistry's emoluments, without any compensation whatever.

9788. In what year did that take place?—In 1862. Perhaps I may be allowed to say a few words with regard to the Chair of Natural History and the Museum. Perhaps I can hardly say anything with regard to the Chair of Natural History, except to this extent, that the present condition of the Natural History Chair is only temporary; but I believe that there is room for very good natural history teaching in St. Andrews—firstly, on account of the very excellent museum, and I may be allowed to bring this evidence forward because the Museum is at present under my charge. Our museum is not what may be called a large one, but it is certainly a large one for the size of our University, and since the munificent donation of Professor Macdonald it is in all departments pretty complete; I should perhaps say a little more than pretty complete, for it is certainly, as regards a teaching museum, in excellent condition. Then again, St. Andrews is better situated for the teaching of natural history than any other of the Scotch Universities. Aberdeen is the only one which can compare with it, but even its bay is vitiated by the large rivers which run into it, while St. Andrews is favourably situated not only in the direction of conchology, and marine zoology, but also as regards other departments; we have a very interesting geological locality, and the botany of the district is also interesting. I believe there is no one of the Scotch Universities which for a moment can compare with St. Andrews as regards facilities for the teaching of natural history, and, I should wish the Commission to understand that I hold that this will come to be an important Chair in the Science Department, if we had some addition to the small sums at present at our command for the support of the Museum. I would just wish to add, as my colleague Dr. Bell is not present, that his Chair of Anatomy and Physiology is now in a condition of efficiency which it never before approached. It primarily was restricted to those subjects, because it is a Chair in the Medical Faculty, but although we have a Medical Faculty we have no medical school at St. Andrews. We have only three classes, two of which, taken together, can constitute a year in the curriculum; we can give one year of the medical curriculum, but we have no school, and we have nothing that could be called an infirmary. Accordingly Dr. Bell has been teaching hygeine, and bringing the Chair much more *en rapport*, not only with the students, but with the public generally, and it is thus at present in a highly efficient condition; and I believe if we had an increased number of students, that it would come to be a Chair of very considerable importance in the scientific department also.

9789. Do you know whether the Natural History Professor has an endowment? — According to the statement of the Commissioners he has about 370*l.* a year, but this scale was struck upon some assumption as to class fees, and he has had no class fees; when he has taught, he has taught gratis, and his emoluments have been much smaller than that sum. The endowment of the Chair may be about 300*l.*

9790. Does the Professor of Natural History receive anything from the Government grant?—Yes, he receives a Government grant about equal to those to the other professors. [*See* APPENDIX V.]

The witness withdrew.

Adjourned to Wednesday next at half-past 11 o'clock.

6, Old Palace Yard, Westminster, Wednesday, 6th March 1872.

PRESENT:

SIR JOHN LUBBOCK, BART., M.P., F.R.S., IN THE CHAIR.

WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

ALLEN THOMSON, Esq., M.D., LL.D., F.R.S., examined.

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

9791. (*Chairman.*) You are Professor of Anatomy in the University of Glasgow?—I am.

9792. Is that a Regius Professorship?—It is under the patronage of the Crown. I may state at the same time that I am professor, by my commission, of anatomy and botany, which has always appeared to me to indicate the connexion held to exist at the time of the institution of the chair between anatomy and the whole science of biology. A distinct professorship of Botany was founded in 1818, when Sir William Hooker was its first occupant.

9793. Are we to understand that there is an independent Professor of Botany?—Yes.

9794. Who is the professor?—Dr. Alexander Dickson. Dr. Walker Arnott was the previous professor, and Dr. Balfour before him.

9795. As regards the teaching of anatomy, you consider it desirable, do you not, that the course of instruction should be made progressive through more than one session of University study?—In truth the course always occupies two sessions. The students of medicine never attend less, and even a general student of anatomy could not obtain a satisfactory knowledge of the subject in less than two years' study.

9796. Is there any practical or laboratory work combined with the present systematic course in the University of Glasgow?—As in all other schools there is practical or laboratory work, in conducting which I have the aid of a demonstrator and several assistants. We have very great opportunities at Glasgow of following out the practical study of anatomy, perhaps the best in the kingdom.

9797. Considering the great development of biology in recent years, do you consider it necessary to separate the chair of zoology and comparative anatomy from that of geology and mineralogy, or do you think it possible to combine them?—I should think that while some parts of these sciences cannot be altogether dissociated there would be a great advantage in separating the two subjects under distinct chairs.

9798. As regards palæontology, would you consider it desirable to combine that with zoology or with geology?—It seems to me that it combines most readily with zoology; it is the complement of zoology, and it could hardly be studied satisfactorily without a knowledge of comparative anatomy and zoology.

9799. On the other hand, I suppose instruction in geology would be almost impossible without some Palæontological knowledge?—Certainly. I presume that in more recent times the most important facts in geology are founded upon palæontological evidence, and it must always therefore constitute a part of geo-

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

logical science. There seems to be no reason why a subject like that should not be taught in part in both courses, in their different aspects at all events. The zoologist or comparative anatomist would take chiefly an anatomical or zoological view, while the geologist, founding upon facts ascertained by the anatomist and the zoologist, would both investigate the stratigraphical relations of rocks, and form conclusions with regard to their palæontological contents.

9800. Do you think that the veterinary institutions in Scotland might be made useful as rendering the study of comparative anatomy somewhat more practical than it is at present?—I think that human anatomy cannot be altogether dissociated from comparative anatomy. I myself use the latter a good deal in the illustration of the human anatomy, because I feel that in the elementary teaching of anatomy I must communicate general views to the student upon the whole subject. My experience as a teacher, like that I think of most others of the day, leads me to believe that such studies must be eminently practical in order to be useful. In so vast a subject as comparative anatomy it is extremely difficult to provide for practical instruction. There is a difficulty in obtaining animals and places for studying them; some means therefore must be adopted to procure them, and so far as the vertebrate division of the kingdom goes I know of no better opportunity for its practical study than that which might be afforded by veterinary institutions under proper management.

9801. Very little has been done hitherto in that direction I think?—Not much. In the museums of the best veterinary institutions there are many specimens illustrative of comparative anatomy, and I can hardly conceive of any person studying the anatomy of the sheep, the horse, the dog, the ox, and the cat, without acquiring a considerable knowledge of comparative anatomy under proper direction. To these might easily be added, the practical study of birds, reptiles, and fishes.

9802. Are you prepared to give the Commission any information with regard to the systematic teaching of chemistry and natural philosophy as at present carried on in the University of Glasgow?—I believe that my colleagues would be glad that I should speak to that subject if the Commission wish for any information upon it.

9803. We should be very glad to hear your views upon those points?—With regard to chemistry I have felt, and indeed I may say the same of natural philosophy, but I have felt it most as a medical teacher with regard to chemistry, that the present course as it has come to be delivered attempts too much, and that it would be desirable, if possible, to limit the teaching of systematic chemistry in the first instance to the principles of the science. This might be accomplished in a shorter time than that occupied by the present course of 5½ or 6 months.

9804. Even in short courses you think that the principles might be taught with advantage?—A knowledge of the chemical properties of bodies and the general principles of chemical combination and analysis might, I think, be communicated in such a course.

9805. (*Dr. Sharpey.*) How long should it take?—From three to four months.

9806. How many lectures a week?—I speak of a full week's work at least five lectures a week, which is our custom in Scotland.

9807. (*Chairman.*) In your opinion a knowledge of such principles would be extremely useful, would it not, even to those who did not intend to pursue the study of the science into its details?—There is this very great advantage in such a system, that as chemistry has now from its importance and its interest become a branch of general knowledge, such a general course would be adaptable for all purposes and for general cultivation. Then it would have the effect of abolishing the attempt to include applications in the course, which applications must necessarily vary according to the school and according to the useful purposes which they may be supposed to serve in different localities. In a great medical school it would be chiefly the application to medicine; or if the study of chemistry were followed by manufacturers, it might come to be to manufactures that the chief attempt to give applications would occur.

9808. Are you prepared to give us any evidence as to the extent to which the scientific instruction in the Universities of Scotland has reference to the improvement of the arts and manufactures?—I wish to add to the preceding answer that it would be desirable to eliminate those attempts at applications from the general course of chemistry and to make them separate, and to establish according to what may appear most desirable in one place or another distinct courses of the applications of chemistry. A very important course I think in medicine would be a course in which the medical student's attention was called to the various applications of chemistry in connexion with medicines, in connexion with physiology, with toxicology, and other subjects. I need not say how many practical applications there are which admit of considerable subdivision in connection with the arts.

9809. Do you think that a more careful scientific education of school teachers would be of great importance?—I have felt, like many other persons, that in Scotland there is a great want of preliminary or school teaching of science, as giving scientific ideas and modes of thinking to our students. We find that many of those who enter the medical profession are entirely destitute of any idea of what science is, and they have therefore very considerable difficulty in approaching the study of the scientific foundations of medicine from a want of the most elementary notions upon science. In the circumstances in which the students are placed, many of them coming from country districts to the University, certainly it would be to them a very great advantage that they should have been able to obtain some elementary scientific knowledge at schools. I should not of course say that such elementary knowledge could come in the place of that which was to be obtained when they enter upon their more systematic scientific studies, but it would have given a taste for science to those persons, and would also have rendered much more easy and more complete, I should think, their study when they entered upon their scientific course.

9810. Do you consider that it would be possible to introduce an elementary knowledge of science even into the village schools?—I have myself given popular lectures, and occasionally in connexion with village schools, and I have found them listened to with great interest, and talked about afterwards by the country people; and I would argue from this that in all the more educated class among them, using that word of course as justly applicable to their condition, the introduction of science would have a very marked effect upon them.

9811. Would it not be of considerable importance also to those who were likely to become managers and foremen of great works and manufactories in the kingdom?—That is a subject upon which I have not very special information or decided opinions. But it has appeared to me, from having been led to consider the subject of technical education, that that is the direction in which the greatest amount of good could be done. I do not doubt that from evening classes, which are the only ones, of course, which could be held for workmen, great benefit would result to the workmen themselves individually, and to the public generally, from their improvement, and that there would be also the great advantage of being able in those evening instructions of a popular kind to select the best young men to be brought on to fuller knowledge. All that I quite admit; but I do not think that the scientific education of workmen can be carried to any great length by such popular lectures or courses given in the evening, although great personal improvement may accrue from it. I have therefore formed the opinion that in order to advance the useful arts by increased knowledge of the scientific principles on which they are founded, the readiest and most effective method is to educate fully in these principles the managers or foremen of the workmen.

9812. (*Dr. Sharpey.*) With reference to primary or elementary schools throughout the country, I think you have expressed yourself in favour of affording some instruction in science, though of a humble kind, in those schools?—Certainly.

9813. Do you think that the introduction of a certain amount of elementary science teaching in those schools would tend to interfere with the subjects which are considered the more essential—reading, writing, and arithmetic—or might it not, perhaps, rather have an influence favouring general advancement?—I am quite of that opinion. In the first place that it would not obstruct in the least degree, and in the next place that it would give a great deal more interest to school teaching, and probably make the young people fonder of school than they are at present. I do not intend to limit my approbation of this to primary schools, although the question, no doubt, had reference to that.

9814. Passing to the higher schools where such young men as those who are intended for the medical profession get their education, is science teaching carried to any extent in Scotland in those schools?—I do not think it is.

9815. For example, is it the case in grammar schools in the burghs, or in what are called academies, in Scotland?—Mathematics is taught pretty generally up to a certain point, and there are lectures on general science given in some, but they are only occasional. Dr. Bryce at one time gave lectures to the boys of the Glasgow High School on chemistry, geology, and natural history, which were listened to with much interest. There is now a teacher of science, Mr. William Keddie, appointed by the town council to give lessons at stated periods in natural history. The instruction is of course elementary, but is very valuable. He and others also give lessons in private schools to a similar class of young people. In the high school of Edinburgh there are three appointed teachers of science, viz. in physiology and chemistry, natural philosophy, and zoology.

9816. Could you inform the Commission as to the qualification of the teachers of elementary schools, or the teachers even in those higher schools to give instruction in science?—I fear that they are not in general so qualified in the elementary schools.

9817. In what does the deficiency of qualification chiefly consist, is it in a want of book knowledge on the subject, or in a want of practical knowledge of the things that they are treating of?—I presume that for the most part they are entirely ignorant of them practically and theoretically. In those schools in general a man is chosen as a teacher of Latin because he knows Latin, and of arithmetic because he knows arithmetic, and has been found to be a good teacher possibly elsewhere, but no inquiry would be made certainly as to his knowledge of any branch of science, and unless there had been already provision for teaching science in a school, that consideration would be left entirely out of view, and it would only be his special qualifications as a teacher of languages or of the branch to which he was chosen, which would be regarded.

9818. Do you think that means could be taken effectually for giving to the teachers even of elementary schools, and still more selected teachers of the higher schools, a sufficient real acquaintance with such subjects as chemistry, natural philosophy, zoology, and physiology, as would enable them usefully to give instruction in those subjects; I mean a knowledge of them practically and by experiment—by the study of specimens and by actual experiments, as distinguished from the mere reading of books?—Yes, I think it possible. I believe that many of those schoolmasters at present are men who have from their education but little taste for science, and who chiefly have perhaps a literary turn; but I think that if there were encouragement for such teachers there should be no difficulty in Scotland in their acquiring such sufficient scientific knowledge—I do not say a very wide range, but quite enough of scientific knowledge in chemistry or in natural philosophy, or in geology or zoology, or in any two of those branches as would answer the purpose that I look to, of combining to some extent scientific teaching with the general teaching of the school.

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

9819. Do any considerable proportion of the teachers that we are now referring to pass through the University of Glasgow?—I believe a considerable number; some after they have been already engaged in teaching come to the University of Glasgow, obtain leave for a time and make out under considerable difficulties the sessions at college, and afterwards return to the business of teaching.

9820. Do you think that such men might be encouraged and also aided in obtaining that extension of knowledge and scientific information which you are speaking of in the University of Glasgow?—Decidedly so.

9821. How do you think that could be best done, would it be through some aid supplied by the State?—Encouragement might be best given, I think, in that form to those who desired to enter upon such a course, and who showed some power or knowledge which led to the belief that they might distinguish themselves in it more than their fellows; perhaps by prizes or bursaries, or money encouragement of that kind which would enable them to carry out this study for one or two sessions at college.

9822. Do you think that the medium for bestowing such encouragement and pecuniary aid should be the Science and Art Department, or do you think of any other way?—That is not a subject upon which I am able to form a decided opinion, but I should think better through the University directly.

9823. You are probably aware that for one or two years back teachers—young teachers chiefly—have been invited to attend courses of practical instruction in London, at South Kensington, conducted by some of the professors of the School of Mines, but aided by assistants; that in the case of comparative anatomy and physiology, last summer Professor Huxley undertook the superintendence of a course of that kind, and was aided by three gentlemen who received remuneration from the Government for it, and were engaged nearly all day in superintending the students' work with the microscope, dissecting animals and the like, and those students received their instruction gratuitously; and more than that, they received a small allowance per week for their maintenance while they were in London. Supposing, now, the Department were inclined to extend that to Scotland and to the Universities in Scotland, do you think that the Universities would gladly join in such a plan?—I think that they ought to do so. I see no reason why they should not, and I think it would be extremely beneficial, provided it did not interfere with the independent action of the Universities.

9824. Do you think that your laboratory accommodation and practical rooms would be adequate when not otherwise employed for such a course?—I should think that our rooms would afford quite sufficient accommodation; the difficulty might rather be in respect to the time of the assistants and the remuneration of the assistants; but I presume that you mean that those are to be provided: the number of assistants would require to be increased and additional apparatus of course provided.

9825. But it would even be practicable, would it not, to obtain special assistants for the occasion in such places as Edinburgh and Glasgow?—We should have no difficulty in finding assistants; such an office is much desired on the part of young men of merit, and I might add perhaps, though it is beyond the subject, that I think that there is very great advantage in the existence and the position of those assistants in connection with the University.

9826. Is the advantage which you speak of an advantage with regard to instruction or as promoting at the same time the carrying on of original research?—In both ways. It encourages original research; it multi-

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

plies the number of individuals who will have a desire to engage in it; it shows them the way of entering upon it and carrying it on, a thing which they might otherwise have been quite ignorant of, if they had only passed through the ordinary university course of lectures and examinations.

9827. Do you think also that it might be a useful mode of training men to take appointments as professors eventually; I do not mean in Glasgow or Edinburgh, but throughout the country?—That is our experience. Several of our assistants have been drafted off to professorships elsewhere, and I think myself, supposing always that the original appointment is a good one, that such an office is unquestionably the best preparation for teaching. Perhaps I ought to add that it seems desirable that an interchange of men between different Universities should take place, so as to avoid the risk of local interest or favour procuring appointments independently of the ability of the teachers.

9828. With regard to the teaching of chemistry in Glasgow, with which you are well acquainted, of course there is a laboratory for students in practical chemistry?—Yes; I can mention one or two facts about that. In our new laboratory about 40 workers may go on simultaneously; that is to say, working on analysis. There are about 20 just now; 20 or 25 is about the number, and it is increasing.

9829. Is that laboratory open the whole day?—Yes; it is open the whole day from 9 to 5.

9830. What assistance has the professor in practical teaching, and also generally in conducting his classes?—The professor of chemistry has two assistants under the ordinances of the University Commissioners, a teaching and a laboratory assistant.

9831. Are those skilled assistants?—Those are both skilled assistants.

9832. Not merely manual assistants?—On the contrary, the two assistants Professor Anderson has at present are men of high scientific acquirements. Mr. Ferguson, a master of arts of our university, is a man of varied and superior scientific acquirements, and Mr. Stewart, the other, is a very skilled scientific chemist.

9833. Do you know what remuneration those assistants receive as such?—As such they each receive 100*l.* a year.

9834. Is that contributed by the University funds?—These salaries are paid from a parliamentary vote. There is also an allowance of 70*l.* for class expenses, paid from the University funds.

9835. Is there not a good deal of commercial analysis carried on in Glasgow in the laboratory?—I believe there is some.

9836. Is there a fee paid for it?—I presume there is for each analysis.

9837. And the professor receives that, does he not?—Yes.

9838. Are not analyses of soils and manures carried on a good deal for the Highland Society?—Yes; that constitutes a large portion of the work done in the laboratory. For these analyses the professor employs other assistants, paid by himself, who, under direction, do routine work of analysis.

9839. Is not your present Professor of Chemistry actually the chemist to the Highland Society?—He is.

9840. You spoke of about 20 workers in the laboratory—are there any classes of practical chemistry of a less elaborate kind?—There is a class of practical chemistry, chiefly adapted for medical students as required by the regulations for medical degrees; that class is held in the summer; about 100 attend it, and that number leads to the necessity of its being divided into two classes of nearly 50 in each.

9841. Do they go through practical exercises?—They go through practical exercises, and I believe in that class the students perform experiments which are indicated by the Professor, first going through a general investigation of the properties of known substances, and then having unknown substances given to them to analyse and detect.

9842. With regard to the class of Natural Philosophy, am I right in supposing that there is now a second professor appointed?—No, that is not so; there is the laboratory assistant, under the Ordinance (Mr. Macfarlane), and Sir William Thomson has appointed in addition a private assistant.

9843. But do those assistants carry on any part of the lectures?—The private assistant to whom I have referred does; he shares the delivery of lectures with Sir William Thomson, that is to say, as the private assistant to Sir William Thomson, and paid by him. Such appointments are made under the sanction of the Senatus, and where prescribed by the Ordinances, by the University Court also.

9844. Which of the two gives a part of the lectures?—The private assistant, Mr. Bottomley, at present.

9845. So that it is not anything superadded to Sir William Thomson's course; it is a part of what he previously included in his course that his assistant now takes up?—If I remember rightly, some change was lately made in the arrangement of those courses by which they were rendered fuller, with the view of carrying on the students to a more advanced degree. It seemed almost impossible for the teacher, if engaged in scientific investigation, to do the whole of this work, and if I were allowed to express an opinion I should say that the association of an assistant, especially such a one as Sir William Thomson has got, conduces greatly to the efficiency of the class.

9846. Did it involve a longer or a more frequent attendance on the part of the students?—I think it is the same number of hours, but there are two hours a day devoted to attendance on natural philosophy lectures.

9847. Could you inform the Commission whether those are all the assistants that the professor of natural philosophy has, or whether he has any other?—Yes. In addition to the two before mentioned, there are two others, one a second laboratory, and the other a professor's assistant, both appointed and paid by the professor.

9848. With reference to the laboratory, has he practical students working in the laboratory?—Yes. I believe there are 12 or 14 at present, but I am informed that there might be as many as 20 or more working in the laboratory.

9849. What is the description of the students that work in the laboratory; are they intended to take charge of manufactories or to become engineers, or what line do they intend to pursue generally in life?—They have been very various. The work which has been done by them has necessarily, from the nature of Sir William Thomson's recent researches, been in special directions; thermo-dynamics, electricity, telegraph instruments, atmospheric electricity, and so forth. I happen to know that several of his very distinguished workers are now medical men, and some are engineers, some clergymen, but I cannot say to what class the others belong chiefly; they have been various.

9850. Have you considered the University of Glasgow and other similarly constituted universities in relation to the carrying on of original researches in science, and how they might be rendered effective for that object?—In the first place I think it is of very great importance that the professor should himself be a man contributing to science in his own department. In the next place I think, as we have almost already said, the assistants ought to be men qualified, not merely to teach in the ordinary branches, but should be preparing themselves at least to be scientific inquirers, and they would have the opportunity of doing original work in the course of their duties, and as far as I can judge many of them actually do so. I think it would be of very great importance to the universities if that view were kept constantly before us in the arrangements connected with the universities, that they are the legitimate and perhaps the best situations in which original scientific work can be going on in Scotland.

9851. For that purpose it would be requisite, would it not, that the professor should have a certain amount of leisure?—It is so, certainly. To most men it would destroy very much the interest of their subject if they had no occupation beyond the drudgery of teaching the elementary branches that they go through.

9852. If the professor were very much occupied by ordinary teaching, of course he would have neither time nor energy to devote himself to original research?—No, he would not.

9853. And that leisure and facility you think could be provided by his having sufficient assistants?—Giving him sufficient assistants seems to be the best mode.

9854. And they would also directly aid in scientific inquiry?—I hold the opinion that strictly elementary teaching is not the best in the hands of assistants, nor the highest teaching, but there is a great deal of intermediate work, as it might be called, in which an assistant can very appropriately carry on the students under the supervision of the professor, and thus relieve him of a great deal of that part of his duty, but I strongly hold that the first impressions of a scientific subject, even though of an elementary kind, are best to be given by the professor himself.

9855. Although the Commission have not yet gone into the question of aid to original research, we may take advantage of your being here to ask whether you have given your thought to the question of how the State might aid original research in science?—I fear it is not a subject upon which I have any general view. I have thought of it of course with reference to the universities, but not otherwise to any extent.

9856. (*Chairman.*) You are not prepared to recommend any modification of the present system of the Government grant through the Royal Society?—Again I have not sufficient knowledge of its details to entitle me to express an opinion.

9857. (*Dr. Sharpey.*) Passing to physiology, is there any provision made for the practical teaching of physiology in Glasgow?—In our new buildings there is accommodation provided for it. The professor has an assistant sanctioned by the Senatus, and with a small allowance as salary, who gives microscopical and practical demonstrations; but from want of resources there is not yet established in Glasgow any sufficient course of practical and experimental physiology, or a course of physiological experiment and research, similar to that which is well known in some other Universities, and we regard that as a very desirable thing to be accomplished, could means be obtained for it.

9858. You refer in your précis to the importance of instituting and encouraging degrees in science in the Scottish Universities, and are prepared to make some remarks upon the scheme proposed for such degrees in the University of Glasgow; probably you would favour the Commission with your views upon that subject?—There is a primary difficulty in institutions like the universities of Scotland from the very natural, and up to a certain extent the very proper, favour in which the old arts degree has been held for ages, producing an indisposition to break in upon that degree, but to those who, like myself, have chiefly looked at the scientific side of the question, it has always appeared that science was too much neglected in connexion with the old degrees. In one university chemistry I think was included in the requirements for the arts degree, and various slight approaches to the including of science have been made, but mathematics and natural philosophy have in almost all of them stood alone as the scientific branches, and still remain so.

9859. Natural philosophy has long been one of the requisite subjects of study for divinity students in Scotland, has it not?—Divinity students go through a full course of arts. Without being required to take a degree they go through a four years' course of arts, or a three years' course, according to the modification which is possible by our regulations for the examination, but the divinity students go through a full course of arts, including mathematics and physics, but not chemistry, before they enter upon their course of theological study.

9860. Did the University Commissioners prescribe any curriculum of study for the degree of Bachelor or Master of Arts?—They abolished the degree of Bachelor of Arts, and prescribed a course of study for the degree of Master of Arts.

9861. But the only scientific subjects, I presume, would be mathematics and natural philosophy?—Those alone. In respect to honours they made a modification, allowing honours to be taken in natural science as well as in several departments already belonging to arts; in mathematics and physical science, in philosophy or in classics, in those three departments.

9862. (*Professor Stokes.*) You stated, I think, that in your University chemistry was required for the Arts degree; is it required as a necessary subject or only optional?—Not in our University, but I think in Aberdeen it was at one time a part of the curriculum in King's College, and natural history in Marischal College. In the United University natural history alone now forms a part of the curriculum for the arts degree.

9863. (*Dr. Sharpey.*) Have degrees in science been actually instituted in Glasgow?—The Senatus had last year the subject fully under consideration through a committee of their number, and the committee has reported a scheme which has now been adopted by the Senatus. It has since received the approval of the University Court.

9864. Can the scheme be presented to the Commission?—I may mention its nature. The difficulty to which I have referred having been felt with respect to the degree in arts, it was thought best to institute a separate degree in science, for which also facilities existed from the fact of its being recognised in the last Reform Act for Scotland as a qualification for the University franchise. The Representation of the People of Scotland Act recognises the Bachelorship of Science as a degree qualifying to vote. There is no mention of a degree in science in the University Act, nor in the report of the Commission of 1858; but the Commissioners took evidence from the professors and others with respect to the question whether there was reason to modify the degree in arts. At that time I suggested that the topics included in the curriculum of arts were too various and too extensive now-a-days, 300 years after the first institution of the degree, to enable any candidate to acquire a sufficiently good knowledge of them to appear for an examination, and that I thought it extremely desirable for that and other reasons that the degree in arts should be modified, somewhat after a plan of divergence in four directions; that a curriculum of two years, which all should be required to go through, including, of course, languages and mathematics, should form a common foundation, and that then the degree might be given to the candidates who pursued their studies and passed examinations in four different sections — classics, literature, and languages for one; philosophy, meaning mental philosophy, for another; mathematics, physical science, and natural philosophy for a third; the fourth, which would probably require subdivision, being natural science or biology and geology.

9865. Would they have an option?—Yes; but that was merely a suggestion, and I have mentioned it only to point to the difficulty which the committee felt, and in consequence of which they abandoned any attempt at that subdivision, however desirable in some respects it might appear. Other considerations have made it more expedient to found a degree in science. I do entertain some doubts whether, the degree in arts remaining as it is, it will be very easy to establish this degree in science without more being done than lies within the power of the Senatus. I should be cautious, perhaps, in expressing such an opinion; but I almost think that the establishment of a Faculty of Science is the most direct and efficient way in which science can obtain that position in the universities of Scotland which it deserves. I do not think that we are likely to succeed in establishing a satisfactory degree in

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

science until some measure of this kind is adopted, and there is a determined concert and action on the part of those men who are more immediately interested in the scientific branches.

9866. You would constitute, I presume, a fifth faculty from the existing professors?—Yes, from the existing professors or from other new chairs which it might be thought right to institute.

9867. What are the Faculties in Glasgow?—Arts, divinity, law, and medicine. I may add that in the scheme which has been adopted by the Senatus, while the scientific branches are recognised separately, they are in each department combined with a part of the arts curriculum. Our degree in law has hitherto been only an honorary degree, and it was held to be desirable that we should have the means of giving a degree upon study, and law is accordingly one of the departments. A certificate in engineering had already been given, and it was considered desirable to raise that into the rank of a degree; that is the second department, viz. of engineering and mechanics; the third department is that of natural science, divided into two, the biological and the geological sections. In each of these three departments the branches of study which were considered most immediately necessary and specially connected with the department are made to constitute the curriculum; and then, in somewhat different proportions, the residuum is made up of a varying number of branches taken from the curriculum of arts at the choice of the candidates. For example, in law the required curriculum consists of Scotch law and conveyancing, which are our two law classes, and any five of the classes in the Arts curriculum.

9868. Which five do the law students usually select?—The classics, the logic or moral philosophy, and the English literature, and this is regulated now in Glasgow by the requirements of the Faculty of Procurators who have established a curriculum, and that determines the choice of certain branches. There is a provision also of an alternative lessening the number of the arts courses by one in the case of civil law or forensic medicine being taken, or in the event of political economy or history being taken in conjunction with any other University course. In natural science, and first the biological section of it, the qualification runs thus: any four of the following five courses, chemistry, anatomy, physiology, zoology including comparative anatomy, and botany. Thus a choice is given between botany and zoology, and then any four of the classes in the arts curriculum. In the Geological Department the rule is geology, chemistry, zoology including comparative anatomy, higher natural philosophy and any four of the classes in the arts curriculum. In engineering science the curriculum consists of mathematics, natural philosophy, inorganic chemistry, geology, civil engineering, and any two of the classes in the Arts curriculum except mathematics and natural philosophy. I confess that I feel there is one want at least in the scheme, and that is that modern languages are nowhere recognised. Although I do not doubt the effect which the study of the classics has in cultivating the powers of application to study and as a good mental discipline for young persons, yet I have always felt that it is not the best discipline for all minds, and that it is even to a certain degree unfair that persons of merit and acquirement in a variety of other departments should from the accidental want of this first step in the general education which has been so long in vogue, be debarred from attaining to those honours, and therefore I have always felt that any system which professes to bring out the scientific talent of the country by encouragement from degrees should be as elastic as possible, and that whilst insisting upon a certain amount, and that a good amount of scientific and general cultivation, it should open the door to a great variety of that cultivation. I think the proposed system somewhat defective in that respect, although I daresay it may be allowed that it possesses some advantages in not restricting the branches so much as in the arts degree. Natural philosophy also might have been with propriety made one of the required branches in biological science.

9869. But on the whole you are in favour of a certain degree of alternation being allowed?—Yes, a choice should be allowed if possible. The system of equivalents is I think a good one in these matters. We do not know as yet how this degree in science may affect the education of students hereafter, it must be tentative, and it should therefore be as wide as possible, so as to give opportunity for those who have been placed in various circumstances as regards their early education to obtain it.

9870. (*Chairman.*) Would you allow that choice from the beginning, or would you insist upon a common groundwork, and then at a particular stage in the education allow the choice to intervene?—I see considerable advantages in a common groundwork, but I am loth to restrict it. I would rather it were entirely open. For example, I can conceive the case of a person who from accidental circumstances has not had the advantage of a classical education, and yet who afterwards has attained very considerable scientific knowledge and general cultivation, and who has in addition a knowledge of the modern languages, who might be quite as well entitled to receive such a distinction as a person who had a smattering of Latin or Greek to begin with. I have no doubt that those who are in that position will make themselves acquainted with the ancient languages to a certain degree in their after life, but I should like the system to be as free as possible in the commencement at all events, until we know better by experience how it will act in bringing forward scientific acquirements.

9871. (*Dr. Sharpey.*) Otherwise very meritorious men, who are likely to make a successful career in science, would be stopped *in limine*?—Certainly.

9872. (*Chairman.*) Much depends, I suppose, on the age at which the University career begins. But in arranging a course of instruction from the beginning, the hypothesis is that you begin with young men, and carry them upwards; in that case, therefore, you might have a common groundwork, and then build upon it the separate courses of instruction afterwards. Your remark in your last answer seemed rather to point to the mode of dealing with men who came before you in the first instance after they had arrived at a certain age, and completed a great part of their education?—No doubt; but even with regard to younger men I should not be disposed to make the rule too stringent; at all events, I should allow of a system of equivalents, or a choice between different subjects.

9873. At what age do the students come generally to the University of Glasgow?—It turned out somewhat unexpectedly, upon making the inquiry some years ago, that the average age of the whole students was 19 years. I believe, however, that that is not a fair view of the age at which a great number of the students do come. That high average arises from a number of persons of a decidedly more advanced age being mixed with the general mass.

9874. (*Dr. Sharpey.*) It would be more instructive, would it not, if they were arranged according to age, and you found out in which year there was the greatest number?—Yes. I find from returns furnished to me that in the present session, out of 309 students of arts joining the University for the first time, nearly nine-tenths are between the ages of 15 and 22 years; nearly one-sixth of the age of 16, and one-sixth of 17 years; 14 are under the age of 15, and 32 above that of 22 years. Of 80 medical students who have commenced their medical course in the present session, 56 are between the ages of 16 and 21 years, 35 between the ages of 17 and 19 years; and both among the arts and the medical intrant students some increase in number occurs between the ages of 25 and 27 years. I may add, as illustrating further the general age of our University students, that the average age of 325 students attending the Latin class during the present session (excluding 32 exceptional cases above 25 years) is found to be 17·8 years.

A. Thomson, Esq., M.D., LL.D., F.R.S,

6 March 1872.

9875. (*Chairman.*) Then your remark refers rather to the management of an institution like the University of Glasgow, which has to deal with a number of persons of mature age, than to such an institution as Eton, or a great public school?—Yes, my remark referred chiefly to Scotland and Glasgow.

9876. But assuming that you had an institution to which the students came when they were comparatively young, would you not rather think it desirable to lay a general groundwork before sanctioning any selection of particular subjects?—I am afraid that would lead me into a discussion of the whole subject of how far classical study is the best discipline.

9877. I only wished to understand whether your remarks referred to the particular case of the University of Glasgow or to your ideas as to the best system of education generally?—They refer chiefly to the latter, because I hold the opinion strongly that there are certain minds that are not improved by any attempt to communicate classical knowledge to them. It is the traditional system which prevails in this country to a great degree, and men have not yet opened their eyes, I think, sufficiently to the great difference amongst persons. It may be a very good mode of discipline for young persons so far as it goes, but I think there are some others that might be better.

9878. Therefore under any system you would allow considerable latitude, would you not?—Yes, under any system I would wish to see the greatest latitude.

9879. (*Dr. Sharpey.*) I presume that you contemplate the case of a lad who may not originally have determined what line he will take, or even whether he should go into the University at all, who afterwards showed some aptitude for scientific study and scientific work, but who had not laid a foundation of classical knowledge, and to whom it would be extremely difficult and onerous to get it up?—In the immense subdivision of labour which exists in this country, and the great increase of the extent of detailed knowledge required, it is clear to me that a man's education in the middle ranks, I mean of those that are to gain their livelihood, must now have some reference to his after occupation, and I should say that it was extremely difficult to find an efficient general system, at least in secondary schools and in universities, which would be entirely free from such reference; that is to say, in all circumstances I think that as soon as possible the education should be more or less adapted to the line of life in which the person is afterwards to be placed. With reference to the professions, I think it is of very great consequence that that should be kept in view from an early period. I judge of this matter very much of course by my own profession; and I have always felt that there was too little attention given to that subject. Indeed, in my own experience, being the first teacher of the medical students, and having inquired what circumstances induced them to join the medical profession, I am grieved to say that in many instances I have not received satisfactory reasons. Purely accidental circumstances seemed to regulate the choice of the profession more than anything else. It was not always any taste for it; it was no knowledge of science that had induced them to decide on following the medical profession. I should like things to be put in such a position that a person going into a scientific profession such as medicine really did so from a love of the science, and I do not think matters will be right until it is so. It is perhaps a Utopian view, but I think a great deal might be done by a scheme of education which would afford the means for a lad to follow his bias. We have little means for that at present. If lads have what may afterwards turn out to be a taste for scientific pursuits, this is liable to be suppressed by the vain attempt to communicate classical knowledge to them, a thing for which they have not the slightest liking. There are others again, differently constituted, who distinguish themselves in literary studies, and it is quite right that they should be encouraged to go on further with them.

9880. (*Chairman.*) Surely that remark rather points to the necessity of placing before boys a considerable variety of mental food in order that they may be able to ascertain in which direction their bias lies?—It is precisely in that way that I look upon it.

9881. Then that shows the desirability, does it not, of making the first steps as general and wide as possible, because until a person has had some general instruction it is really a matter almost of guess work and chance for him: he cannot tell in which direction his tastes would probably lie?—I am quite aware of that, but unfortunately the general opinion in the country and the habits and the whole arrangements of our old educational institutions are adverse to it.

9882. (*Dr. Sharpey.*) With reference to the institution of a Faculty of Science what advantage would you expect to accrue from that specially?—In the first place those professors belonging to it would have an opportunity of meeting together and considering and comparing their views upon scientific subjects. In the next place, they would stand in a more influential and important position if they had a Faculty of their own than if they were merely a minority or a small fraction of another Faculty, or mixed up as at present with different Faculties. Their consideration would be directed much more towards one point, that of securing a proper position for science and the efficient teaching of it. I think there are many directions in which the establishment of a Faculty of Science would not only be useful, but it seems to me to be very strongly called for.

9883. Then they would have authority to represent as a Faculty their views to the Senate?—Yes, it would not, however, necessarily be constituted of men belonging to one Faculty alone; we have at present, I think, several professors who belong to more than one Faculty, and of course this would apply to the Faculty of Science.

9884. Are you prepared to inform the Commission as to your view with respect to the extent to which the examinations of students are useful?—I have throughout my whole career as a teacher pursued a system of examination, first of all orally, and more recently, that is to say, within the last 15 or 20 years, by written questions, and I think in most subjects it would be impossible to conduct a large class efficiently without engaging in those examinations. On the other hand there are attendant evils, more especially the one which belongs also to multiplied examinations for degrees and preferments, that of causing preparation solely for examinations. It is the great evil of the day. The great bane of teaching at the present day is that we are not teaching students for the desire of knowledge. I mean that they are not impelled simply by a desire of knowledge in general, but rather of knowing only that which will serve their purpose at the next examination. Examinations, if the students could be taken unawares, would be good, but that is almost impossible mechanically to arrange. I feel very strongly indeed the harm that is done by over examination, and by this preparation. It seems to extend itself to all branches of education now. I find in regard to classical education that it is frequently not an effective real knowledge of the language that is acquired. We often find, for example, that a boy learns to translate a certain author or a portion of an author, but he does so with very little acquisition of a real knowledge of the language. I have met myself, and that has called my attention to it very strongly, with many instances of persons to whom I have referred a short passage, of some very simple author, "I have not read that book, sir," is the answer. The student had read some other book of the same author, and was quite prepared to translate and give you the parsing, the grammar, and everything, upon that part, but he had not gained much knowledge of the language. Precisely the same defect belongs to our scientific and professional teaching; so that I cannot help thinking that there is something radically wrong in our system of instruction. It is the great pressure I have no doubt, that is the cause of the whole evil; in fact it is the present state of the world, one might say almost the rapidity with which we live, that is the cause of the whole thing;

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

but I do think that steps should be taken to make that time devoted to preliminary studies, which in Scotland is sometimes six and sometimes eight years, more productive. Perhaps I may be allowed to say that I am an advocate for a thorough system of examinations in teaching classes especially. Perhaps the observations previously made apply more strongly to other examinations, such as those for degrees and preferments; the class examinations I hold to be a very important adjunct to the other duties of a professor.

9885. (*Dr. Sharpey.*) Are you able to give a practical character to your examinations?—Very much, and in a subject like mine the more practical the better, so as to correct some of the faults to which I have before referred. In my teaching of anatomy I have of course great opportunities in a laboratory where work is going on of examining practically, and my assistants examine there also; but I have also pursued the system lately of making the pupils bring their work into the public class-room, and give demonstrations before their fellows of their anatomical work; and I have found that that has had a very good effect.

9886. (*Chairman.*) Do you think that there is any greater difficulty in detecting mere cram in those subjects with which you are particularly connected, than there is in the other branches of knowledge?—In truth in my subject it is perfectly easy to detect cram, but notwithstanding that the students still persist in it. There is no difficulty whatever; a few minutes is time enough in my subject to examine a man and at once to distinguish between real knowledge and cram, but notwithstanding all this I am sorry to say the habit is so strong and the custom so prevalent that the students persist in the attempt to cram.

9887. In natural science generally it is peculiarly easy, is it not, to detect cram?—Yes, in practical examinations you have the advantage that you can at once distinguish between information which is got by mere reading or cram, and real knowledge of the subject.

9888. (*Dr. Sharpey.*) I think the Commission will be interested to learn from you some information respecting the scientific collections of the Glasgow University, the Hunterian Museum, and others?—The Hunterian Museum is a general collection which Dr. William Hunter by his will in 1783 bequeathed in trust to the then existing professors of Glasgow College and their successors, together with 8,000*l.* for the erection of a building and the maintenance of the collection. The building was begun in 1804, and the collection was transferred in 1807 to Glasgow.

9889. Now it is removed, is it not, to the new University buildings?—It is, but the collection is not yet placed in the museum.

9890. The old building is demolished, is it not?—Yes. The museum and a considerable part of the old University buildings.

9891. Will you go on to mention the nature of the collection?—It is a general collection, comprising a library of rare books and manuscripts, coins and antiquities, some pictures, and a large number of specimens illustrative of natural history and anatomy. It has received considerable additions in some departments since it came into the possession of the University.

9892. The anatomical department is a very important part of that museum, is it not?—Yes, it is, and it has received some additions, but not such as to bring it up to the position which it should occupy at present, there being no funds.

9893. Is any part of the 8,000*l.* originally bequeathed to the museum available for its maintenance?—There is not, unfortunately, the whole of that sum together with the interest which had accrued upon it having been expended in the building required for keeping the museum at the Old College.

9894. By what means is it maintained now?—By the funds of the University.

9895. Could you say what amount is laid out for it annually?—The whole sum in 1870 was 294*l.* and some shillings.

9896. Does that include the attendant?—It includes a salary of 100*l.* to the keeper who is the Professor of Natural History (not necessarily so, but is so at present), and 100*l.* to the assistant keeper.

9897. Is it open to and visited by the public?—It was so up to a certain time, when we were disturbed by the removal.

9898. But henceforth will it be so?—We expect that when arranged it will be much visited by the public.

9899. It will be free to them, will it?—That must depend upon whether the University can arrange to have sufficient attendance. The only reason against it would be the increased expense of attendants and cleaning. The University otherwise I am sure would be much disposed to throw it open. A small fee was previously charged, and upon certain occasions it was much reduced, so that very large numbers of persons at certain seasons of the year visited the museum.

9900. Are you able to make use of the specimens in the museum to any considerable extent for the illustration of your lectures?—It has been done to a certain extent. Of course that would be quite legitimate in connexion with the natural history course, because specimens for that course could scarcely otherwise be obtained.

9901. You have a special collection, have you not, for your class?—Yes, I have shown occasionally specimens from the Hunterian Museum at my class; but I have a sufficient museum of my own as well as a collection purchased by the University from the heirs of the late Professor Jeffray, which two constitute a large illustrative class museum, and I am in the habit only of showing some preparations from the Hunterian Museum, of which I cannot find other illustrations.

9902. Besides those two collections which you have mentioned are there any other scientific collections in the University of Glasgow?—Perhaps I ought to mention next in connexion with the University two institutions as connected with teaching, the Botanic Garden, and the Astronomical Observatory. The Botanic Garden, not being the property of the University, but the University having privileges in connexion with it in consequence of a large subscription formerly made to it.

9903. That is maintained, is it not, by private subscriptions?—It is a private institution; it belongs to a company or set of shareholders. In a part of the garden there is a collection of plants systematically arranged for botanical instruction, of which the University students make use; and I may here mention that the University, aided by a private subscription, recently purchased the extensive dried herbarium and the library of botanical works belonging to the late Professor Walker Arnott, together with the large and beautiful collection of microscopical specimens of the Diatomaceæ made by himself.

9904. How is the observatory maintained?—The observatory is a university institution. It belongs to the University, and there is a collection of instruments there, of which some are very valuable, especially a refracting equatorial which belonged to Sir William Keith Murray and which is an excellent instrument. There is also a reflecting telescope which was given by Lord Breadalbane, which is the property of the University.

9905. The University of Glasgow has rather a large income, has it not, independently of any aid from the State?—I should not say so of available income. They have considerable sums which are appropriated to special purposes—bursaries, scholarships, salaries to professors, and so on, but of available income they have very little.

9906. The Professor of Astronomy receives a salary, does he not?—He has a salary of 220*l.* a year, and from the University he receives for an assistant 100*l.*

9907. Has he a house with the observatory?—Yes, he has.

9908. Does he lecture in the University or at the observatory, as a professor?—He gives lectures as professor in the University, and practical instructions at the Observatory. He has a class room in the University

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

buildings, and there is a small fund for the purchase of astronomical instruments from Mr. Wilson's bequest, amounting to about 45*l.* annually. There is also a sum appropriated from the Meteorological Department of the Board of Trade, as it is one of their stations for meteorological observations. That has been a very great advantage in connexion with the Observatory. Dr. Grant has, I believe, felt it so; but he could give more precise and full information as to the astronomical department than I can.

9909. I suppose that those are all the collections, properly so called, of the University, except the library of course?—With regard to the collection to which I have referred in my own establishment in connexion with anatomy, which is one of human anatomy with a considerable amount of comparative anatomy, there is no reason why those parts of that collection which are suitable for the general museum should not pass afterwards into the general museum (as I mean to leave my collection in the University), retaining that portion of it which is immediately useful for class purposes in connexion with mine. I believe that Dr. Anderson is the possessor of a collection of specimens of chemical and mineralogical substances. As to natural philosophy, of course there is the apparatus of natural philosophy, and there is a small fund, I think, from Mr. Wilson's bequest for the purchase of apparatus; but we have no separate fund for that from the University. The class-collection of materia medica substances which belonged to Dr. John Cooper was given to the University, and Dr. Cowan has it in his class room. I think that these are the whole of the collections of any extent.

9910. May I ask you what your opinion is with regard to the advantage of the establishment and maintenance of museums throughout the country, accessible to the public with a view of promoting scientific knowledge; I refer particularly to museums of zoology and geology?—Considered as a collection of those objects with scientific views, I have always thought that there was a disadvantage in subdividing museums. There ought to be, not perhaps one only, but several large museums, throughout the country, which may be made more or less complete by absorbing all the most valuable specimens, so as to fill up scientific series; but on the other hand, if we look to the dissemination of a taste for science, and a general knowledge of it, it is quite obvious that we must subdivide collections, and make such collections as are most readily obtained, fitted for those purposes; and therefore I am greatly in favour of the establishment, in some places it may be, of collections of typical specimens, in others it may be with most advantage of local specimens illustrative of local objects; in fact, all such collections as will increase the interest of the public in their subjects and in scientific knowledge. In Glasgow I might give as an example, there has long existed a considerable collection of general and natural history objects in the institution called Anderson's University, and more recently the University has so far, through its professor of natural history, favoured the establishment of a museum of this kind in the public park situated near the University; and we think, so far from injuring the interests of the Hunterian Museum, considered as a scientific collection, that we may even be able to assist the Hunterian Museum by exchanging specimens and duplicates, and allowing such a collection to be viewed by the public, and increasing their interest in its subjects, while all specimens that really fill up a series or are valuable in a scientific point of view, might be obtained by the Hunterian Museum as the more complete and scientific collection.

9911. I am referring particularly, not to the question of one great central museum in one locality as distinguished from two or three in the same locality, but rather to the distribution of such museums over the country in different towns and centres of population?—It seems to me that the people in general will never acquire much interest in science unless they have practical illustration of it; that as models of machinery, and especially working models, would lead them to take an interest in the construction of the real machines, so likewise objects in natural history would lead them to consider and take an interest in the questions connected with those subjects. Both are necessary for purposes of education and to give that interest in science which we all wish to promote, I think that those museums spread over the country would have a very beneficial effect.

9912. Do not you think that they might be rendered very useful to the science teaching in schools in the neighbourhood?—Clearly they would. In fact such teaching could not be effective without having the use of such preparations.

9913. As to the means of supplying materials to such museums has it occurred to you that there are any sources which might be available for it?—Perhaps from want of habit and want of attention we have not availed ourselves of the means which are existing. I am sure that in great towns like Glasgow or Liverpool there are quantities of interesting specimens in natural history which different people are keeping as curiosities which could be thrown into museums with useful effect; and that we scarcely yet know what the resources of the country are in that respect.

9914. Supposing that the means of maintaining a special officer connected with the great Hunterian Museum at Glasgow could be found who might collect specimens from the sources which you refer to, and arrange them and distribute them, of course expenses being paid, might not that be a mode of improving local collections?—I think that the person connected with the Hunterian Museum might be advantageously so employed.

9915 And also to distribute redundant specimens to localities where they are wanted, and to superintend exchanges, because in some localities they are rich in particular specimens and defective in typical specimens, so that they could afford to give something in exchange, which would be a means of completing their series. I mean completing in a certain way, because there must always be two or three grades of museums between the highest and the most simple,—and do not you think that some means might be taken with aid granted from the public money, for the purpose of improving and rendering more useful the collections throughout the country in the way hinted at?—I have no doubt that that might be very useful. We will suppose a man who has the knowledge which is required, and the only difficulty, which is only a partial one, would be with regard to gifted specimens.

9916. Do you keep all specimens which are gifted whether they come to be redundant or not?—Nominally we do.

9917. (*Professor Smith.*) I do not think you mentioned to us what was the title of the degree in science which it is proposed to grant?—Bachelor of Science. We have not, as in Edinburgh, proposed to institute a Doctor of Science. We have not seen our way to that yet. In Edinburgh, I believe they have rules both for a bachelorship and a doctorship.

9918. Has that question been considered at Glasgow?—It has been to a certain extent.

9919. Could you state what were the reasons that determined you not to propose the institution of the doctorate?—I think it was more from doubt as to the proper additions which would be required to be made to the qualifications for the bachelorship than from any other reason. I do not think that the committee of the Senate saw their way clearly to a proper distinction between the doctorate and the bachelorship. They considered it enough as a first step to propose the bachelorship.

9920. I understand from you that the Bachelorship in Science would be given upon examination?—Quite so.

9021. Would it be requisite in that examination that the candidate should satisfy the examiners in all the subjects that were mentioned in each branch of the subject?—Generally that would be so, I do not pretend to say how far in the arrangement of the examination the board of examiners might be entitled to

A. Thomson, Esq., M.D., LL.D., F.R.S.

6 March 1872.

take a view of the qualifications of the candidate as a whole, or whether each examiner would have to report, and whether his report would be taken as final. I myself have the view that to some extent at least it is fair to the candidate that the judgment should be that of the whole board rather than that of the individual examiners.

9922. (*Dr. Sharpey.*) Especially on a subject which is not professional like medicine?—Yes.

9923. (*Professor Smith.*) If I understand the scheme correctly it was a characteristic feature of it that a considerable part of the examination should really be literary?—Not necessarily so, because a choice of the subjects from the curriculum of arts is allowed to the candidate.

9924. Would it enable the candidate to avoid all the literary subjects?—I believe in most instances it would, but possibly in the case of law it would be difficult, because there are five subjects from the curriculum in arts, and in that department the candidate could not well dispense with the literary training.

9925. Is the degree simply that of Bachelor in Science without stating the particular branch in science in which the degree is obtained, or is it one and the same degree in all cases?—It is the same degree; there is no distinction. As far as I can recollect no method of distinguishing them was suggested, although, no doubt, some plan of distinction would be desirable, and might be contrived.

9926. (*Dr. Sharpey.*) How is it with the degree in engineering, is that a Bachelor of Science degree with a special certificate for engineering?—That was at one time the intention, but I see no rule provided for it by letters indicative of the distinction.

9927. (*Professor Smith.*) Has this been considered in connexion with it, the distinction between the two degrees of Bachelor of Science and Doctor of Science, whether the doctorate of science might not be given in connexion with original work of some kind, and in that way whether a distinction might not be made between that and the bachelorship?—The matter was considered, but not so as to lead to the institution of the doctorate. There was only a partial consideration of it with regard to engineering.

9928. (*Dr. Sharpey.*) What would be your own opinion as to the point which Professor Smith has inquired about, as to whether one mode of earning the doctorate of science might not be for original work done in any particular branch?—That view had not been presented to my mind, otherwise I think I might have looked upon it favourably. I had only thought of some increase of study, and I saw much difficulty in carrying out that plan with effect; but upon conditions securing original work, I do think that there might be very great advantage in giving a separate doctor's degree.

9929. (*Chairman.*) Are you prepared to give the Commission any information as to the nature and extent of the accommodation provided for science teaching and investigation in the new university buildings at Glasgow?—Yes; I lay before the Commission four reduced copies of Mr. Scott's plans, comprising the basement, the ground floor, the first floor, and the upper floors, upon a scale of ⅛th of an inch to the foot, and plans of those parts of the buildings which contain the scientific laboratories on the larger scale of one quarter of an inch to the foot. These plans, as they are figured, will sufficiently explain the nature of the accommodation. I also exhibit to the Commissioners plans of the means adopted for securing heating and ventilation throughout the buildings, as constructed by Mr. Wilson W. Phipson, C.E. These consist mainly in the forced introduction, by means of a fan driven by steam, of fresh air drawn from a considerable height, and suitably warmed, into the different apartments, together with a system of extraction by the connection of the vitiated air flues with elevated shafts surrounding the smoke flues. Open fire-places are provided in the smaller sitting-rooms. It will be observed that one side of the great quadrangle is left vacant for the extension which may be required after a lapse of years; the part printed without shade has not yet been completed.

9930. Where are those buildings?—Upon an eminence at the west side of Glasgow, about two miles from the Exchange, which may be considered as the centre of business. The ground has a very quick slope down to the river Kelvin. The town is extending rapidly in this direction, and all round even to the west, but the river Kelvin surrounds two sides of the ground, and upon those two sides a considerable open space will be left permanently, partly in the University grounds and partly in the public park of the city. To the west there is also an open space occupied as students' exercise ground; and beyond that, the site of the Western Infirmary, a sick hospital which is now being erected there, and which will serve for the clinical instruction of the University Medical School. To the north is the district of Hillhead, in which dwelling-houses are extending. The main building is 540 feet long by about 300 broad, consisting of two quadrangles divided by the public hall, which is not yet completed. The open space within those quadrangles is 180 feet square, and in addition the chemistry and anatomy buildings extend outside the main building to the east. The natural philosophy laboratory is within the main building; the chemical laboratory is in the octagon outbuilding to the east.

9931. How many students is it fitted up for?—It is considered that it will hold 40 working at the same time; it would hold more, but 40 easily, allowing a little more than six feet square for each worker.

9932. Is there a class laboratory?—Yes. You will observe on the plan the professor's room, the apparatus room, the furnace room, the private laboratory, and the laboratory of research. With respect to laboratories, I may remark that the complete form of building belonging to a quadrangle placed on such an elevation as that forming the site of our buildings, has one disadvantage in not favouring the extension of surrounding buildings of an irregular form with adjoining courts, and in a style not controlled by the general architectural features of the main edifice. There are not less than five departments in which such accommodation is desirable, viz., Natural Philosophy, Chemistry, Anatomy, Physiology, and Natural History, and it is obvious that a great extent of ground is necessary to secure this.

9933. Is there anything which you would like to add to what you have already told us?—In connexion with my last observation I would only wish to say that our new buildings, while forming a magnificent gothic pile, such as might be expected from the design of the accomplished architect, furnish the professors and their assistants and students with teaching accommodation of such extent and convenience as cannot fail to be of great use to general and scientific education. [*See* APPENDIX V.]

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

6, Old Palace Yard, Westminster, Friday, 8th March 1872.

PRESENT:

WILLIAM SHARPEY, ESQ., M.D., Sec. R.S., IN THE CHAIR.

GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

JAMES McCLELLAND, Esq., examined.

J. McClelland, Esq.

8 March 1872.

9934. (*Chairman.*) You were lately President of the Institute of Accountants and Actuaries?—Yes, an institution in Glasgow incorporated by Royal Charter.

9935. And you have been managing director of Anderson's University?—I have been a trustee of Anderson's University for 37 years.

9936. Will you have the goodness to inform the Commission as to the origin and constitution of that institution?—Anderson's University was instituted by John Anderson, Professor of Natural Philosophy, in the University of Glasgow. The constitution is laid down in his will dated the 7th of May 1795, and a codicil thereto dated the 4th of January 1796. I have brought with me a copy of the will, which is now produced. The management of the University has been conducted from the death of Professor Anderson to the present time in the terms of his will. The University is governed by 81 trustees, and these trustees are divided into nine classes: first, tradesmen; secondly, agriculturists; thirdly, artists; fourthly, manufacturers; fifthly, mediciners; sixthly, lawyers; seventhly, divines; eighthly, philosophers; and ninthly, kinsmen of the testator and namesakes; Anderson being the name

9937. Who appoints or elects those trustees?—The will appointed the 81 trustees, and originally named and designed them, and their acceptance of the office made them trustees of the institution until they absented themselves six times. When they absented themselves six times, each class of nine had a right to elect their own companions in the class so as to fill up the vacancies, and in this way the 81 trustees have been kept up to the present time.

9938. But practically do they fill up the vacancies?—They do fill up the vacancies. A man is not allowed, unless under exceptional circumstances, to be a trustee under the will unless he attends at least the quarterly meetings which are held every three months.

9939. Are the managers elected by the trustees?—Yes, nine managers are elected by the trustees, by ballot, and those managers attend to the detail and the working of the University.

9940. (*Professor Stokes.*) Is there one manager for each class, or do they elect the managers as they please?—No, they are elected more with a view to their efficiency and interest taken in conducting the business of the University.

9941. (*Chairman.*) Are there a secretary and other officers?—There are a secretary and an officer whom they call in Scotland a janitor, to take charge of the buildings.

9942. Are the Professors formed into faculties?—The Professors are classified into faculties under the following heads: first, the Faculty of Arts, including physics or natural philosophy, mathematics, and chemistry; secondly, the Faculty of Medicine, including chemistry, the institutes of medicine, the practice of medicine, anatomy, surgery, midwifery, materia medica, medical jurisprudence, ophthalmic medicine, surgery and clinical instruction, and botany; and there are also the Faculty of Law and the Faculty of Theology, but those faculties are both in abeyance at present.

9943. What foundation did Dr. Anderson leave for the establishment of this institution?—The chief foundation was contained in his will. With the exception of philosophical apparatus and personal effects there was little else than the formation of the system mentioned in the will wherewith to carry out the intentions of the founder.

9944. Then how has it been established and maintained?—It has been maintained up to the present day in its present efficient condition through the perseverance of the trustees and the occasional gifts from time to time of the citizens of Glasgow, and also I may add by the purchase of property and mortgaging their property to banks, the University paying the interest.

9945. Still they must have had capital for that purpose, how was that obtained originally?—The only way in which they had capital was by the purchase of property, and making a mortgage upon the property almost to the full extent of the value of the building.

9946. Then that would partly, of course, be supplemented by the fees of the students?—Yes. No endowments have been attached to any of the Faculties, and the professors are dependent upon fees from their students, and until lately they were obliged to pay rent for lecture rooms in the University. The subject of rents being paid by the professors has always been a very sore question with the managers, and I myself have helped a good deal to get the debt paid in order to free the professors from paying any rent, and I am glad to say that in its present state we are in a situation to dispense with such payments. I think that the first legacy was left by James Yeates of London, who bequeathed to the University in 1829 a fifth part of the Island of Shuna, an island in the estuary of the Clyde, which at present yields 40*l.* a year.

9947. What has been the attendance of students in recent years?—As to the attendance of the students I have got a return of the students who have attended the scientific classes apart from what are called the popular classes in 1870–71.

9948. What has been the attendance on the chief scientific classes of the institution exclusive of medicine?—The attendance on the scientific classes in 1870–71 was as follows: On natural philosophy, taught by Professor A. S. Herschel, a son of the late Dr. Herschel, on sound and light, 34 students, and 74 students in applied mechanics; 108 students altogether. Those lectures are supplemented by popular lectures.

9949. Might I ask whether those lectures are mathematical natural philosophy, or whether they are chiefly independent of mathematics?—Independent of mathematics. In mathematics Dr. Alexander Laing is the professor, and he also teaches the lower branches of mathematics, algebra, and trigonometry, and also arithmetic for lads and boys, and most successfully leads them to the higher branches of mathematics; there were 120 altogether last year in his class.

9950. Do you know how far he goes in mathematics?—No: he goes certainly through a considerable portion of Euclid. The present professor of chemistry is Dr. Thorpe, who succeeded to Dr. Penny.

9951. He has, in the first place, to give a course of lectures, has he not?—Yes. The winter course consists of a daily scientific course, 63 attending.

9952. That I understand applies to the systematic lectures?—Yes. Then there is the class of practical

J. McClelland, Esq.

8 March 1872.

chemistry, which has operations in the laboratory, attended by 27 students, and of medical chemistry, attended by 4, making 31 altogether who attended these classes in that year.

9953. What is the nature of the practical chemistry which the 27 attend. Are they workers all day in the laboratory?—Only a portion of the day, but our president, Mr. Young, will be better able to speak to that.

9954. And how has it been with regard to the medical chemistry?—In the summer session in the laboratory there were 5, and the practical medical chemistry had 42 students, making the number attending the winter and summer courses of Dr. Thorpe 141.

9955. In the summer is the practical medical chemistry, as it is called, a course of practical chemistry specially adapted to medical students?—Yes.

9956. The five students in the laboratory I presume are working students who remain all day?—Very likely. Perhaps young men, belonging to counting-houses, going abroad, who wished to understand practical chemistry.

9957. The Institutes of Medicine, taught by Dr. Watson, include physiology, I presume? There are 10 professors in the Faculty of Medicine, and in 1870 they had 424 students altogether.

9958. In the class of Institutes of Medicine is the instruction confined solely to lectures, or is there any practical class connected with it?—I believe in all of them there are practical classes, especially in that of Dr. Buchanan, but in the Medical Jurisprudence class it is merely by lecturing. Dr. M'Call Anderson's subject is the practice of medicine. He is a gentleman well known to the medical profession, from his "Treatises on Diseases of the Skin."

9959. As regards anatomy, taught by Dr. Buchanan, in the course of the year how many students does he have?—162 in 1870.

9960. And of course that comprehends those attending the lectures, and also those in the dissecting room?—Yes, it includes the dissecting room as well. He lectures both orally and with diagrams, and with the human body.

9961. Are you aware whether there is abundant means for the study of practical anatomy in the Andersonian University?—As far as regards the accommodation for students of anatomy, and also for the dissecting room of anatomy, I believe it is only inferior to the University of Glasgow. The plans which I produce will show the area of both the dissecting room and the lecture rooms, so as to make any one judge that is acquainted with the subject whether there is sufficient accommodation or not.

9962. Are they amply supplied with the material or subjects for practical anatomy?—Yes.

9963. Altogether how many are there attending on the scientific classes?—793 in the year 1870-71.

9964. Are there classes also in languages?—Yes. I may say with regard to the Faculty of Medicine, that the gentlemen who are professors are elected by the trustees, and by ballot, and the greatest care is taken to have men of talent. Candidates look upon being elected to Anderson's University, although they have but little emolument, and have been obliged to pay for the rooms, as a stepping-stone to a higher position, and they have often been translated into other Universities. As you are aware, our late friend Dr. Thomas Graham, Master of the Mint, held a position there, and was translated to London.

9965. Does that mode of election apply to all the scientific professors?—Yes, to all the scientific professors.

9966. With regard to the popular classes in the evening, have those been instituted from the beginning?—The popular classes have been carried on from the earliest period of the University, and they have lately increased in favour and interest through the liberality of the friends of the University.

9967. Did Dr. Anderson especially contemplate popular courses of lectures?—His chief object was the instruction of the working classes of Glasgow, and especially he included lectures to ladies upon scientific subjects. Even in 1795, Dr. Anderson was so progressive in his ideas that he besought the trustees to have lectures for ladies upon scientific subjects.

9968. Have those lectures ever been given?—Soon after the constitution of the University, they were given by Dr. Garnett, Dr. Birkbeck, and others. Dr. Thorpe, the present Professor of Chemistry, lectures to ladies, and a large number of ladies attend the musical lectures. Dr. Birkbeck in 1800 gave a familiar exposition of mechanics and general science to 500 artizans. They met weekly for three months, and were gratuitously instructed. This proved to be the origin of mechanics' institutes.

9969. There have been gifts, have there not, especially destined to support the popular lectures?—Yes; the first was from John Freeland, of Nice; that gentleman gave 7,500*l.* to the University under a special deed, a copy of which I now produce. I am one of the surviving trustees under it, and the interest of this grant is to be applied in teaching three subjects to the working classes: 1st, chemistry; 2nd, mechanics and experimental physics; and 3rdly, human anatomy and physiology. Mr. Ewing, of Glasgow, in a similar manner, has set apart under another deed 3,000*l.* (and a copy of that deed I also produce), the interest of which is to be applied in securing the delivery of lectures upon the theory and history of music, on the lives of eminent musicians, and on such branches of acoustics as may be necessary to illustrate the science and practice of music.

9970. Have those popular courses of lectures been well attended?—Yes, very well indeed. It is a remarkable increase. Previous to those gifts being made the numbers were small compared to what they are now. During the last term, in the popular classes in natural philosophy by Dr. Herschel there were 251 students, in anatomy and physiology by Dr. George Buchanan, 327 students; in chemistry by Dr. Thorpe, 394 students; in music as scientifically taught by Mr. Brown, 110 students; in the art and practice of vocal music by Mr. McLelland, 134 gentlemen and 64 ladies; making 198 students; and in botany by Mr. Hennedy, 177 students; making in all attending the popular classes of Anderson's University 1,457 students in 1870–71.

9971. That aggregate, I presume, does not represent separate persons, as several may attend more than one class?—I did think so, but the return shows otherwise; it does not come out exactly 1,457 separate students, but the statement is that of 1,100 attending those classes, exclusively of music, 977 students attended one class only, 112 students attended two classes, 17 students attended three classes, and two students attended four classes; so that the majority of them attended on their favourite subjects, either physiology or chemistry or natural philosophy.

9972. How frequently are those popular lectures given?—They are given during the winter months; 26 lectures once a week; therefore the three lectureships occupy three days of the week. Mr. Herschel has one day, Dr. Buchanan has another, and Dr. Thorpe another. The condition is that they are to get 100*l.* for the 26 lectures, but in order to secure efficient teaching, if a professor is absent from the lecture, unless from sickness, 1*l.* is deducted from him. We were afraid that it would grow into assistants being asked to give the lectures, and we wished as they were well paid, to have efficient teaching, and this mode has been adopted and practised with success.

9973. Are there any examinations carried on in those popular classes?—Yes, I believe so, in physiology. I do not know whether Dr. Thorpe does it in chemistry, but I think that both in natural philosophy and physiology there is an examination, but to what extent I am not aware.

J. McClella
Esq.

8 March 18

9974. Perhaps it may be voluntary ?—Yes.

9975. Are there any prizes or certificates of honour awarded ?—The only way in which there are certificates of honour or prizes is that young men have the liberty of answering the questions of the Science and Art Department at certain periods of the year, and if the students are found to be efficient in answering the series of questions proposed by Dr. Huxley, or any other examiner, he gets a present of a book from the Queen, and he may go up to get a medal. One boy at our secular school at Glasgow has got the gold medal.

9976. Does the institution receive any aid from the Science and Art Department ?—None ; but when the qualified teacher examines, he will be entitled to an honorarium as in schools, if he succeeds in making efficient students for the year.

9977. Do you know the history of any students that have attended those popular lectures in the Andersonian Institution, and have distinguished themselves in any way either in manufactures or commerce or in science ?—I am not qualified to give an opinion upon that subject further than tracing young men from the secular schools in Glasgow which I have mentioned, to Anderson's University, where they got their teaching in science in addition to what they got at the secular school. I can mention three instances in which young men belonging to the working classes have been raised to a higher platform by attending the classes of the secular school, and attending the University, and are now practising as surgeons in Glasgow. Two other youths from the same school were lately among the senior students of the Medical School of Glasgow University.

9978. They came through the secular school to Anderson's University ?—Yes. First from the school to Anderson's University and then to the Glasgow College to get a degree.

9979. Do the Professors share the small fee that is paid by the students ?—Yes, independently of the 100*l.* a year, they are entitled to a share of the 2*s.* 6*d.* paid by each of the students.

9980. So that a student may attend one of those courses for 2*s.* 6*d.* ?—Yes, for 2*s.* 6*d.* during six months in the year, and he may read books out of the library which contains upwards of 6,000 volumes ; he may read throughout the year.

9981. Are they entitled to have the books at their homes ?—Yes, they get them at their homes ; and this is managed by a committee of the working classes themselves, irrespective of the trustees altogether.

9982. Is the library maintained solely by the share of the fees ?—Now it is ; that is of the popular classes library. There are other libraries under the University connected with the institution, such as Dr. Anderson's library itself, and also a medical library ; but those 6,000 volumes are the books that are applicable to the popular classes, and those have been got together by the young men themselves.

9983. And that popular library, so to speak, connected with the popular scientific classes is maintained by a share of the fees ?—Yes, and by the gratuitous attention paid by those young men in the administration of it.

9984. Is the accommodation in the University adequate for the purposes of the institution ?—The aggregate amount of attendance upon all the classes in the University in 1870–71 was 2,640, and my belief is that there are portions of the University which are yet unoccupied, so that you may draw from that statement that there is sufficient space for the 2,640 students from time to time ; but the plans which I produce, and the measurements of each room will give any qualified person a distinct notion upon that subject.

9985. There has been an important gift to the University lately, has there not, by Mr. Young, for establishing a Chair of Technical Chemistry ?—Yes. Mr. Young has given the very handsome sum of 10,000 guineas for the purpose of establishing a Chair of Technical Chemistry attached to the University. Mr. Ewing, another friend of the University, previously had bought a building for extending the powers of the University at an expense of 2,100*l.*, and that building is now being fitted up for the accommodation of the Technical Chair.

9986. Is that close to the original building ?—It communicates with the original building. From Mr. Young the Commission will get fuller information upon that subject.

9987. Have eight bursaries been founded in connexion with this Chair ?—Yes. There are eight bursaries of 50*l.* each attached to the Chair of Technical Chemistry. In addition to the gift which Mr. Freeland has made of 7,500*l.* he has also made a gift of 5,000*l.* to the trustees to pay off the debt, but I have ascertained from Mr. Young that through his own liberality and that of Mr. Ewing (thinking that Mr. Freeland had forgotten it), the debt has been paid off. It was upon a letter which I wrote to Mr. Freeland in 1868, stating what I wanted him to do, that he gave us 5,000*l.* He did not know that the debt had been paid off by Mr. Young and Mr. Ewing, so that this 5,000*l.* is to the credit of the University for University purposes. The condition that Mr. Freeland made without knowing that the debt had been paid off was that the professors should be freed from the payment of rent in future, and they are now freed.

9988 (*Professor Stokes.*) You stated that Professor Anderson had in view the instruction of the working classes, may I ask whether the students who attend the lectures, not including the evening classes, belong mainly to the working classes ?—The students who attend the Faculty of Medicine and the Faculty of Arts are, I believe, qualifying themselves for a profession. They may belong to the working classes, and many of them come from a great distance to attend Anderson's University, many from Ireland, and many from the north. I have not had an opportunity of knowing whether they do belong to the working classes, but they certainly do not belong to much of the upper class.

9989. Then that class of students are pretty much the same as those who frequent the University, are they not ?—Yes, very much alike ; I mean in the Faculty of Medicine and the Faculty of Arts. When you come to the popular classes then the range is most extraordinary. I have got from Mr. Lang, the chairman of the popular evening classes, the occupations of 1,100 of them, and they include architects, bakers, bankers' clerks, druggists, drysalters, mechanical engineers, fleshers, gardeners, joiners, printers, compositors, warehousemen, salesmen, and even medical students attend those popular classes ; so that attending those popular classes there is a perfect mixture of the well-to-do working classes of Glasgow. I will put in the following table of the occupations of students in the popular classes :

J. McClelland, Esq.

8 March 1872.

TABLE of OCCUPATIONS of STUDENTS in Popular Evening Classes.

Accountant	10	Flesher	1	Portioner	4
Architect	3	Gardener	3	Portmanteau maker	1
Baker	3	Glassmaker	1	Post Office employé	1
Bank clerk	7	Goldsmith	1	Potter	1
Bank teller	2	Grocer	7	Power loom tenter	1
Blacksmith	8	Gunmaker	1	Printer and compositor	14
Bookbinder	5	Hairdresser	3	Railway servant	4
Bookseller and stationer	8	Hamcurer	1	Reedmaker	2
Bootmaker	8	Hatter	2	Sawmaker	1
Bottler	2	Hotelkeeper	1	Ship agent	1
Box-maker	2	Housefactor	2	Shipwright	4
Brass finisher	1	Inland Revenue officer	7	Shopman	6
Bricklayer	2	Inspector	1	Stereotyper	1
Brewer	1	Insurance agent	2	Storeman	5
Bronzer	1	Ironmonger	2	Sailmaker	1
Builder	1	Ironmoulder	3	Salesman	22
Butler	1	Jeweller	1	Sampler	1
Cabinet maker	3	Joiner	10	School (at)	52
Carver and gilder	2	Labourer	2	Seal engraver	1
Cashier and bookkeeper	23	Land surveyor	4	Soapmaker	2
Chandler	1	Law clerk	6	Student	23
Chemical student	1	Lithographer	7	Surgeon	1
Chemist (practical)	20	Manager	3	Tailor	6
Civil engineer's apprentice	7	Manufacturer	1	Teacher and pupil teacher	20
Clerk	226	Manufacturer's agent	1	Timekeeper	1
Clothlapper	4	Mechanic	8	Tinsmith	2
Coal merchant	1	Mechanical draughtsman	9	Traveller (commercial)	14
Commission agent	6	Message boy	4	Upholsterer	2
Confectioner	1	Metal refiner	1	Warehouseman	100
Cooper	3	Mining engineer	2	Watchmaker	10
Coppersmith	1	Modeller	1	Waterproofer	1
Corkcutter	2	Naval draughtsman	1	Warper	2
Custom house officer	2	Painter	4	Wire rope maker	1
Dentist	7	Paper ruler	1	Wood carver	1
Draper	10	Pattern-book maker	1	Wood merchant	1
Drysalter	3	Pattern designer	5	Writer	1
Druggist	60	Philosophical instrument maker	6	Medical student	15
Dyer	15	Photographer	2	Merchant	13
Electrotyper	1	Piano tuner	1	No profession given	46
Engineer (mechanical)	121	Plate glass silverer	1	Total	1,108
Engine-keeper	2	Plumber	3		
Engraver	11	Porter	2		

9990. Can you tell the Commission what influences the class of students to which I referred, to attend the Andersonian Institution rather than the University of Glasgow?—First, from its popularity; secondly, from its cheapness; and thirdly, from its central situation in a population, reaching with the suburbs upwards of 560,000 people. The institution is in the very centre of them, and thereby they are nearer their own habitations in the evening.

9991. Although the institution is called a University, it does not, I believe, grant degrees?—It cannot do so, it only acts under the will of Dr. Anderson; but I have always maintained that if we got quit of the debt under which we have laboured now for so long, we were as much entitled to a charter from the Government as any school for the teaching of science in Great Britain.

9992. As much so as the University?—Yes, because the University drafts our professors away to them, so that we are upon a par with them in that respect.

9993. (*Chairman.*) You would not propose that there should be an additional body in Scotland established to grant degrees, would you?—That is a question on which at present I am not in a position to give an opinion. Should the question be raised, difficulties would arise with many who think a central authority should be established from whom might emanate degrees for the whole nation.

9994. Was there no kind of constitution conferred on Anderson's University under what is called the Seal of Cause by the magistrates and corporation of Glasgow?—Yes, there was a Seal of Cause granted by the magistrates and corporation of Glasgow, but it is of no use whatever.

9995. It gives you no privileges? —None whatever.

9996. You cannot hold property, I believe, except as trustee? That is so. I have put in the plans so as to show the available space for the teaching of the sciences which I have been giving an account of already, and I may take the liberty of adding, from a good deal of personal knowledge of Glasgow, and from a personal knowledge of education otherwise irrespective of my own profession, that I know of no place so well fitted as a nucleus for the training of scientific teachers to send out among the people of Scotland as Anderson's University.

9997. That is to say the teachers of elementary and science schools?—Yes.

9998. What facilities for study would they obtain in the Andersonian University?—The attendance on the University classes of course.

9999. Would there be the means of giving them instruction practically in the different branches of science, chemistry, natural philosophy, and also natural history, physiology, and comparative anatomy?—Yes, certainly, if they paid for it.

10,000. Has it occurred to you how the expense of such instruction might be defrayed. Would the teachers be able to pay for it themselves?—A portion of them might, but I think it would need to be supplemented by the Government, in the same way as we supplement those popular classes. You see the influence that the assistance to these popular classes has had upon the attendance. Before we got Mr. Freeland and Mr. Ewing to give 100*l*. a year to each of the professors, the attendance was small compared with what it is now, but by getting really efficient men of science to come forward and give popular lectures to the students attending in the evening, the supplement has had a most important effect.

10,001. So that a moderate endowment in your case has really had the effect of giving greater efficiency?—Yes, giving greater efficiency both to the attendance and to the teaching.

10,002. You spoke of the professors in the institution having a share to a certain extent in the fees paid by the Science and Art Department for the students who are successful. Could you say how much in the aggregate has come in the course of a year to the professors from that source?—No, I am not aware of that.

10,003. I presume that the young men comprehended

J. McClelland, Esq.

8 March 1872.

in this large list as attending the evening classes are engaged throughout the day at their several occupations ?—Yes, they are engaged throughout the day, and they apply their minds thus after the day's work, and it is a most excellent thing to see them apply their minds to scientific study in place of going to the beer shops.

10,004. There are 121 mechanical engineers put down in the table which you have handed in. I presume you consider that these classes are very useful to them ?—It is of great importance for mechanical engineers to attend some of those classes—in fact all the classes—as it is just leading them into a better class of work when they go to their own employment of mechanical engineering, both in the manufacture of steam engines and iron ships, and in almost all departments of the iron manufacture, which is a most important branch of industry in Glasgow, and the more attention you pay to it, the more efficient you will get those young men to be in their respective callings.

10,005. Have you considered at all the advantage of what are called technical schools for giving instruction in applied science, especially as applied to manufactures ?—No, I have not done that further than having early in life, upwards of 22 years ago, established along with my friend Richard Cunliffe of Glasgow, a school in Glasgow called the Secular School, and as that school was instituted for the purpose of endeavouring to show to the country what a national system of education should embrace, we in place of giving catechisms and formularies introduced certain subjects of science, and those subjects of science have been taught to the children after they have completed their instruction in reading, writing, drawing, and arithmetic, up to the age of 13 and 14, and for the last 22 years it has been and is now successfully going on educating them in the same way.

10,006. That was instruction in general science ?—Yes. The three subjects that we took up were popular physiology, beginning with instruction from the human skeleton, and leading the boys on by means of Marshall's diagrams. Then we took up the subject of chemistry, the table of the schoolmaster being utilised with the chemical apparatus under it, and with the gas at the side, and when a lesson in chemistry was given it was not from words but from acts at the table, Then again we took up another subject, which we think of the greatest importance, and that is the subject of social economy as taught in the excellent books on the subject of my friend William Ellis. We have taught those three subjects, and we think that it has had a great deal of influence in elevating the working classes attending those schools to a higher platform among their fellow men.

10,007. Of course a fee was paid for attending that instruction ?—Yes, they paid larger fees than in the catechism schools around us, but still the children flock to the school, and now we have not less than from 160 to 180 or 200 children attending.

10,008. How many teachers are required for such a number of pupils ?—We have two males and three females ; we allow a female to conduct the elementary teaching of both boys and girls.

10,009. Do the whole or the greater part of the pupils take advantage of that instruction in science ?—The greater part of them, I think, when they get to the age rising from 10 upwards, and they go on until they leave the school.

10,010. And it is found that they can be very efficiently taught as far as the teaching goes, receiving a sort of groundwork of scientific knowledge at that age ?—Certainly ; we have found it most completely so. At that age they take the instruction most readily ; when we began it, the boys used to say, "Well, it is as good as a moral lesson, this instruction in anatomy ;" the teacher instructed from the skeleton in the bones of their own body.

10,011. It was not found at all to weaken the instruction in the ordinary branches of education ?—By no means ; I think that the results of 22 years' teaching have proved that.

10,012. I suppose, by giving more variety, it makes school-work more agreeable ?—Yes ; the great thing is to have teachers who are really efficient in their calling, as an immense deal depends upon that.

10,013. How did the teachers in the secular school acquire that knowledge of science which you speak of ?—That was a subject which was greatly discussed and embarrassed us at the time that we founded the school. A young man was a teacher in a Sunday school when I became acquainted with him. I thought a good deal of his ability, and I advised him to leave off his trade and to educate himself for a teacher. We then sent him both to Anderson's University and the college to learn science, both chemical science and physiology and anatomy, and did not allow him to open his lips in teaching the boys on these subjects until we thought he was fully qualified, both to understand the subject and to convey it efficiently to the children, and the consequence is we have gone on successfully until now. Mr. Mayer is well known as a young man of science in Glasgow, and his instruction has been so ample and his ability is so great that he is fit to pass an examination for a doctor of medicine ; he is also a most efficient chemist, and has stuck to the school. Fortunately, he married one of our school mistresses, who is very well qualified also, and those two have been the means of keeping the school together in a most efficient state ever since they have been teaching in it.

10,014. Is his duty confined to the teaching of science ?—No, not at all. After the children are taught in the alphabet and reading they are transferred to him and his assistants in writing, drawing, and arithmetic, and any other branches that may be taught in the school, but every week the lessons in science proceed.

10,015. Is there any other point which you would like to give evidence upon which has not been elicited, for instance, with reference to the aid required, if any, to carry on the institution or to give more efficiency to it ?—My impression from the work which I have gone through in practical education for so long, is that a moderate endowment efficiently conducted is the way to get the schoolmasters of this country taught efficiently in matters of science. As I have often stated, at the meetings of the British Association and Social Science Association, and at various meetings in Glasgow, you are powerless to conduct scientific education until you educate teachers in science.

10,016. You refer, do you not, to the general dissemination of a knowledge of science ?—Yes, amongst the teachers, and the people of course will imbibe it the moment the schoolmaster begins to understand it. I may mention one thing to show that it is absolutely necessary now to give efficient scientific knowledge to schoolmasters. There are two normal schools in Glasgow, one belonging to the Church of Scotland, and another belonging to the Free Church. Under the late rules of the Education Department each young man must undergo certain literary examinations before he gets power to become a schoolmaster under the Department, but it is only a permissive power to learn any portion of science, and any one knows if a young man has not much money what a permissive power means, he neglects it. But I understand that there is an alteration now, making it imperative upon a young man to learn a portion of science before he gets his certificate. In consequence of this permissive power being only in the curriculum some of the young men attending these normal schools have come to our school and paid a fee to Mr. John Mayer for the purpose of teaching them science in order that they may be qualified in this department in their own profession.

10,017. You have mentioned the facilities which would be afforded by the Andersonian University for the practical instruction of teachers in science ; is there any other direction in which you think that its usefulness might be extended ?—In many, espe-

J. McClelland, Esq.

8 March 1872.

cially in technical education; but that would apply to youths after they leave school, because I do not think you could give much technical education to a child before he has learnt other things. There is plenty of room for it in the Andersonian University. I believe that there is instituted just now an association for the purpose of promoting technical education in the west of Scotland, and one of their objects is to make Anderson's University a nucleus for their work.

10,018. Have you attended particularly to that question of technical education and do you consider that such education should comprehend the work of a factory or an ordinary workshop, or should it be merely the study of particular branches of science that have a particular bearing upon the future occupation of the student?—It certainly should have a bearing on the future occupation of the student, but I have not attended minutely to the subject of technical education further than this. I know that in making a mechanical engineer, the first thing that a mechanical engineer would ask a boy to do before being introduced as an apprentice, would be to go to a joiner's shop and learn himself to cut out work in wood, which is their first occupation when they go into engineering works, and unless he does that he is left behind.

10,019. I apprehend from what you say that you consider that that skill would be best got in a joiner's shop and not in a school?—Yes, it cannot be obtained in a school.

The witness withdrew.

J. Young, Esq.

JAMES YOUNG, Esq., examined.

10,020. (*Chairman.*) You have been long acquainted with the teaching of science in Glasgow and elsewhere?—Yes.

10,021. Is there any information upon that subject which you would like to afford to the Commission?—I should like so far to supplement what Mr. McClelland has said of the great desirability of science being well taught in Glasgow.

10,022. Both generally and especially to the working classes?—Generally to all classes. I think that the teaching in Anderson's Institution of Natural Philosophy and Chemistry to all classes of the community, which was begun about the end of last century and continued ever since, has given Glasgow its high position in mechanical engineering and manufacturing chemistry. I cannot see why Glasgow has been so far before other places in those departments except in that way; although a man did not attend those classes, he heard in the workshop from the men who did what they learned there, and knowledge was diffused in that way. My father attended Dr. Birkbeck's class in natural philosophy and what chemistry there was at that time, and he was willing enough to exhibit his learning in the workshop.

10,023. I think that you yourself were a pupil of the Andersonian University?—Yes; I was a pupil there when Mr. Graham came, and for some years after.

10,024. I think you assisted Mr. Graham there, did you not?—Yes.

10,025. You must have much considered the question of the advantage that instruction in science can confer upon the industry of the country, and perhaps you would favour the Commission with your views upon that subject. You yourself founded the Chair of Technical Chemistry in the Andersonian Institution in Glasgow; what do you desire should be taught there?—My idea is this, that in ordinary theoretical chemistry they should teach chemistry as a branch of general education, which every man ought to know, but if a man wants to be a chemical manufacturer the Professor of Theoretical Chemistry has not time for that, he has an immense deal to do and far more to do than can well be done to teach his pure science, and the class of technical chemistry is to teach an intended manufacturer the principles on which the chemical manufactures depend, more than he could get in the scientific chemistry class.

10,026. I presume that the instruction in the technical school would comprehend not merely instruction by lectures, but practical work by the student himself?—Practical work by the student himself is the main thing, that is what he works at all day.

10,027. I think from what I have heard of your opinion before, that you conceive that there should be no attempt in a school of applied science to teach actual manufacturing work, but to give a thorough acquaintance with the branches of science which are applicable to that work?—That is my opinion, that they should attempt to teach ordinary work is a mistake altogether. I have been asked if we had a dye-work in the Andersonian Institution, we have not, but the man who wrought beside me in the Institution, 36 years ago, is, I believe, the best dyer and calico printer in Lancashire at present.

10,028. He gained a good knowledge of the scientific principles of his art in the University, and they were carried into effect in the workshop afterwards?—Yes, in the works.

10,029. And it is upon that principle that you founded this Chair in Glasgow?—Yes, that was my idea.

10,030. Do you think that there are opportunities for the foundation of other Chairs of a similar kind?—Undoubtedly.

10,031. What others would you think desirable?—We are very anxious just now to get the same kind of thing to the applications of natural philosophy, just the same kind of idea. I may mention that this technical chemistry is a success.

10,032. In what way is that shown?—We have got a number of very good efficient hard-working students who are interested in the thing, and who have taken in hand to devote themselves for three years to the study.

10,033. And do they pay a fee for this?—Yes, it comes to altogether something under 20*l.* a year which is paid by each student. Then we have a number of men who saw the necessity of such things, helping poor students by bursaries. We have nine of them at 50*l.* a year.

10,034. How long is that bursary continued?—For three years: it is expected that he will work there for three years. The bursar must have a knowledge of scientific chemistry, and be able to set about ordinary chemical analysis, else we do not admit him. We do not pretend to teach in the technical school the elements of chemistry. I may mention that there is a growing demand for such a thing. The scientific chemistry has been already very much benefited by it in the number of students. Last year the Professor of Scientific Chemistry, Dr. Thorpe, had five laboratory pupils, and he has got 20 now.

10,035. Is that with the view to preparing themselves for the technical course?—I understand so. The Professor wrote the other day and said, "The technical Chair has so re-acted on me that I have no more room; I cannot take more pupils," and we had to give him another large room to accommodate his pupils.

10,036. How are those bursaries conferred; is it by examination?—Yes, by examination; that is to say, it is advertised that competitors will be examined and a number of young men come forward. They must be of a certain age before we can admit them at all, either 16 or 17, and if they succeed in passing this examination, of course we take the best of those that come, and they get the bursary.

10,037. And do they go through a three years' course?—That is intended. It is an understood agreement; there is nothing written about it, but it is understood that they devote themselves to the study for three years; that is the bargain. The bursary

J. Young, Esq.

8 March 1872.

may be withdrawn if they fail to show approved progress or conduct themselves improperly.

10,038. I presume they work the whole day?—Yes, the whole day. They are just laboratory pupils in the same sense as the laboratory pupils in scientific chemistry.

10,039. We all know that you must have had occasion to see and experience the great advantage of scientific knowledge in its applications to practical purposes. I presume that the directors of industrial works and foremen and the more intelligent of the workmen, through means of an acquaintance with the principles of science, applicable to their art, would be enabled to make signal improvements in manufactures?—Yes; I cannot conceive of improvements being made in chemical art without a knowledge of the principles. A chemical work is often reduced to a system, going on apparently perfectly well, but if the manager or the director has not a knowledge of chemistry something will happen, and he will not know what is wrong, and the more he tries to put it right the farther it goes wrong.

10,040. And again with that knowledge he is able to make advances and improvements in his art?—Yes; that is the only way in which I conceive improvements can be made. Anything else must be mere haphazard.

10,041. And in that way, therefore, scientific instruction, given to those who are to engage in industrial occupations in the arts and manufactures, eventually tends to the good of the community?—Certainly. I know nothing that tends more to the good of the community than improvements in manufacture. It is almost miraculous the change that has taken place in the value of chemical products in our own time. I can myself recollect when the bichromate of potash was 5*s.* a pound, a short time before that it was 15*s.* and as high as a guinea, but it has been sold for years back at 4½*d.* or thereabouts, merely from the improved methods of manufacture.

10,042. But still it is found to pay at 4½*d.*?—It has been sold for years at 4½*d.* I think just now it is about 7*d.*, but for several years it was 4½*d.*

10,043. And at a profit?—People went on doing it and the same people are in the trade still. The low price has led to new applications of the substance in the manufactures with a large gain to the country. Chlorate of potash, which you recollect was a very rare substance, is 10*d.* a pound now, and it would be more than that per ounce in former days.

10,044. In this new building that is being erected for the school of technical chemistry, would there be accommodation also for one of natural philosophy?—We are not erecting a new building, we have applied the building that Mr. Ewing gave us. It was all in order, and we commenced work at the beginning of this winter session, and it has gone on without a jar ever since.

10,045. Would there be accommodation sufficient there also for a class of applied natural philosophy?—Not any. It would require another room. We already have as many students as we can well accommodate there.

10,046. Have you any prospect of obtaining that class of natural philosophy?—I think there is a very great prospect. The same gentleman, Mr. Freeland, who gave us so much, has sent us 2,000*l.* to help to endow it. It is a thing that cannot depend upon the fees, it could only live by an endowment, as it must be under an efficient teacher.

10,047. In the Andersonian University you have experienced, have you not, the disadvantage of the want of endowment, because your good professors have been drafted away to other places?—That is the rule. We have been a training school for professors. London and the University of Glasgow have taken some of our best.

10,048. With reference to facilities that might be afforded in the Andersonian University for the instruction of teachers, do you think that such would be practicable?—Yes, very practicable. We have now a large class of medical students which we call the practical class, and we are fitting up a large room for them alone, and they come an hour and a half or two hours a day. Another hour and a half or two hours could be applied perfectly well in the same room to the instruction of teachers. We have the apparatus there, and the tables, and benches, and gas, and everything.

10,049. Could the professor undertake that additional duty, or would he require assistance?—He would require assistance. The professor has quite enough to do besides; he is working hard at original research.

10,050. You consider it, do you not, an advantage, in a place where science is taught, that the teacher should also be a man given to original research?—If he is not, I think it would be a great misfortune.

10,051. But in order to have sufficient time free for that he must be relieved of much of the drudgery of teaching?—Yes, he must be a man of that turn of mind to lead his students to be thinkers more than mere students. The great advantage of having a philosopher for a teacher is that he leads a man to higher thoughts than a mere teacher does.

10,052. How could additional assistants be paid?—That is a matter for consideration.

10,053. In London for two or three years back there has been instruction not merely by lectures, but practical instruction given to teachers through the Science and Art Department, which afforded the means and paid the expenses of it; do you think that it would be a wise application of public money to do the same thing in other institutions as well as South Kensington?—I would answer that generally by saying that I cannot see a better application of money than by teaching science. I cannot possibly see a more useful thing that money could be put to than giving instruction in science.

10,054. Who is the Professor of Technical Chemistry?—Mr. Bischoff. His father was Professor of Chemistry and Geology in Bonn, and he had a good deal of working with his father in bringing out books which he wrote upon those subjects.

10,055. What is his emolument altogether?—He receives first the interest of part of 10,000*l.* amounting to 200*l.* per annum, and he receives the fees from the students, bursars included.

10,056. Is no part of that fee required for the maintenance of the establishment, the current expenses, and so on?—I think we have provided for that independently; the interest of a further portion of the 10,000*l.* is applied to providing the premises and keeping up the laboratory.

10,057. So that if there are 20 students it would be nearly 400*l.* that the professor would get?—Yes, and he has the 200*l.* endowment besides. He has a very good assistant whom he pays well, and which comes out of his own salary.

10,058. Is there anything else that you would like to inform the Commission upon as regards the Andersonian Institution, or any other question connected with scientific instruction or the extension of science?—No, I do not think of anything. I am very anxious that scientific instruction should be advanced or disseminated as widely as possible. Mr. Harvey, who is to give evidence before the Commission, is one of our Trustees: he is well acquainted with arts and manufactures; he was assistant to Dr. Thomas Thomson.

The witness withdrew.

A Harvey, Esq.

8 March 1872.

ALEXANDER HARVEY, Esq., examined.

10,059. (*Chairman.*) You have had the advantage of hearing the statements of the other witnesses?—I have heard Mr. McClelland, and concur very much indeed in what he has stated, and I believe Mr. Young is correct in all he has said. As to my practical experience in chemistry, I was formerly assistant to the Professor of Chemistry at Glasgow, the late Dr. Thomas Thomson, for four sessions, and since then I have been practically employed in the chemical management of the St. Rollox Works, Mr. Tennant's, and subsequent to that I had the charge of Henry Menteith and Company's Works, Turkey-red dyers and calico printers, and since 1838 I have been engaged in business for myself as a dyer. I retired from my business about two years ago, leaving it to my sons; so that all I can say is, that my early knowledge of chemistry has had a tendency to carry me through all those different branches.

10,060. You must have well considered, and had much experience of the advantages of scientific knowledge in the carrying on of any manufacture that was connected with science?—Yes.

10,061. In your opinion, to what extent can scientific knowledge applicable to manufactures be acquired in a school or University?—The principles can be acquired, but those are acquired in the study of elementary chemistry. The application is then entrusted to the technical department, or practical department, and whatever branch of study the young man intends to carry out, or object that he intends to follow after, he directs his studies to that, practically, as he has the opportunity, in the laboratory, of putting any operation in practice that he may wish to carry out ultimately.

10,062. Still you would draw a line, I presume, between that and the actual work in a factory?—Most distinctly, because you require to be sufficiently acquainted with it before you can carry it out on a large scale.

10,063. You could not imitate, effectively, in a science school, the actual work; you could not there carry on in miniature, so to speak, a chemical manufactory?—No; in the case of calico printing establisments, or a chemical manufacture, you could not upon a large scale do it. You can eliminate the elements, but you cannot carry it out in practice on a large scale in a school.

10,064. Are you a Trustee of the Andersonian University?—Yes; I am one of the managers, and have been so for about 20 years.

10,065. Have you any suggestion to make to the Commission in addition to what has been stated by the former witnesses?—Nothing further than what has already been mentioned by those who have preceded me. It is very desirable that Mechanical Chairs should be instituted, as well as Physical Chairs.

10,066. Can you trace the history of any of the pupils of the Andersonian University that have acquired distinction in after life as scientific manufacturers?—Yes, I know two or three.

10,067. Putting aside Mr. Young, you know some others?—Mr. Young is a very good illustration. There are two or three young men that I have known, who attended those classes in the Andersonian University, who have risen to places of distinction in their own particular branch of trade. For instance, there are two men that I have kept my eye upon who have risen to distinction as calico printers. One is Mr. Lindsey, who, after studying at the Andersonian chemical class and popular lectures, became very eminent as a colour mixer in a calico printing establishment owing to his scientific knowledge.

10,068. Improvements in that branch depend very much, I presume, upon scientific knowledge?—Yes. Dr. Stenhouse is a very good illustration.

10,069. He has become a distinguished scientific chemist, has he not?—Yes. I believe his elementary studies were in the Andersonian University. He learned his chemistry there.

10,070. He has directed his attention very much, I think, to dye-colours?—Yes, particularly to the properties of the lichens and cudbear, and some of those colours.

10,071. Has there not been a great improvement of late in reference to the crimson dye of madder?—Yes, the colouring principle of the madder root is now formed artificially.

10,072. Is that alizarine?—Yes; and Mr. Perkins is now manufacturing it to a large extent in the neighbourhood of London.

10,073. Has that cheapened the article much?—It has tended to keep down the price of madder, because there is a certain margin that he requires for his manufacture that madder never can get above; alizarine produces a much purer colour and equally fast with the natural madder. The artificial alizarine requires less brightening, because you have the pure colouring matter. In dyeing with madder you get a brown colour as well as the scarlet or red, and this brown colour has to be dissolved away before you can have the bright colour, whereas alizarine gives you the colour bright almost at once.

10,074. And the artificial production of alizarine by a chemical process, tends to keep down the price of the madder?—Yes.

10,075. I suppose the consumption of madder is very large in this country?—Very large indeed. The madder itself is now being converted into what they call garancine. It is reduced in bulk and weight two-thirds of its original weight, and then, of course, the transit of it from Avignon, or from Turkey, Holland, or any other place, is reduced considerably.

10,076. Still the money value, I presume, of imported madder must be very great?—Yes; the money value of garancine is much more than that of madder.

10,077. I mean the aggregate amount of money paid for garancine in this country every year must be a very large sum?—Yes, a very large sum.

10,078. And the making of artificial alizarine tends to check it?—Yes, it has a tendency to keep the price of madder down to a margin sufficient to allow a profit upon the artificial product.

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

6, Old Palace Yard, Westminster, Friday, 15th March 1872.

PRESENT:

WILLIAM SHARPEY, ESQ., M.D., Sec. R.S., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
BERNHARD SAMUELSON, ESQ., M.P.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

ALBERT GÜNTHER, Esq., F.R.S., examined.

A. Günther, Esq.
15 March 1872.

10,079. (*Chairman.*) You are Master of Arts, Doctor of Medicine, Doctor in Philosophy, and Fellow of the Royal Society?—Yes.

10,080. And you are an assistant in the Zoological Department of the British Museum?—Yes.

10,081. Is yours a special department?—I have a part of the Zoological Department under my charge; that is to say, the collections of reptiles and fishes, besides many other specimens preserved in spirits.

10,082. You are personally acquainted, are you not, with the majority of the natural history collections in Germany, and the chief of those in France and Holland?—I am acquainted with the majority of the museums in Germany, and with the Muséum d'Histoire Naturelle, in Paris, and with the most important Dutch zoological collection, the Ryks-Museum at Leyden.

10,083. With regard to the German museums, will you state generally where they exist?—They are formed almost in every large town, but the most important, I should consider, are those connected with the Universities. I believe the number of Universities in Germany is at the present time 16. I am not quite sure of the number, but I believe that that is so, and every one of those Universities has got one or several museums attached to it, as a means of scientific instruction, namely, a zoological museum, a botanical museum, a palæontological museum, &c.

10,084. Are those generally maintained or subsidised by the Government of the country?—There are very few which are without connexion with the Government, or do not receive any subsidy from it; by far the greater number of them are entirely supported by the Government. This refers more particularly to the University institutions.

10,085. Will you favour the Commission with information respecting those which you consider provincial museums?—Those museums have been chiefly founded for the purpose of being places of amusement to the people. They are the oldest museums, and they consisted in the first instance chiefly of collections of curiosities, objects of natural history or of ethnology, or the like. In course of time they took a particular tendency and developed themselves into natural history collections, but they did not take up at the same time the intention of combining scientific instruction with the establishment. At the present time those museums, as they exist, for instance, in Stuttgart, in Darmstadt, and in the formerly free towns of Hamburg, Bremen, and Frankfort-on-the-Maine, are very large establishments, and contain various collections of natural science, but they do not profess to have the object of instructing the public more than in a most general way.

10,086. Are those museums ever connected with local societies for the prosecution of science, especially natural history?—Certainly, in this way, that several of the most important museums have been the cause of such societies of natural history being founded. The Stuttgart Museum, for instance, has given rise to an important provincial society for the advancement of the knowledge of the natural productions of South Germany. Then again the Frankfort Museum has an intimate connexion with the Senckenberg Society. Again, the Bremen and Hamburg Museums are connected with similar societies.

10,087. So that those museums are rather for the purpose of the advancement of science than of scientific instruction?—Yes, they tend more to encourage a taste for science among the general public in this indirect manner.

10,088. Are there any such collections that are connected with schools or gymnasia, or that are available for the purposes of those schools and gymnasia as places of instruction?—They are certainly most insignificant. When I look back to the gymnasium at Stuttgart, at which I received the early part of my education, it was provided with as small a collection as almost every private gentleman may have in his house; but it was perfectly sufficient for the purpose of elementary instruction, particularly as our teacher was in the habit of going with us at certain intervals to the Museum of Natural History.

10,089. So that those museums of which you spoke previously became available for the purposes of instruction of the pupils of these seminaries?—Yes, certainly, and it is the desire of the directors that the teachers of those seminaries should always avail themselves of them for their scientific instruction.

10,090. By bringing pupils to the museum?—They bring pupils to the museum, but the teachers do not bring them so frequently to the museum as they ought to do. I cannot say that the instruction in natural science in those lower schools in Germany is as much developed as it ought to be.

10,091. It is desirable, is it not, that the teacher should demonstrate and explain the specimens to the pupils whom he takes to the museum?—Yes, and so he does.

10,092. What is the nature of the contents of most of those museums?—The contents comprise objects of all branches of natural history.

10,093. In the University museums in particular, are the collections for the most part limited to typical forms for the purposes of instruction?—Yes; in the University museums their means are too slender to allow them to engage in making very large general collections, so that they are necessarily obliged to limit themselves to types; that is to say, to representatives of the most important families or genera.

10,094. But in some cases there are very extensive collections, are there not, as at Berlin, for instance?—Yes, the Berlin Museum is one of the most important collections in the world at the present time.

10,095. In Berlin is the Natural History Museum distinct from the Anatomical Museum?—Entirely, although they are lodged in the same building.

10,096. And the specimens of comparative anatomy are in the Anatomical Museum, are they not?—Yes.

10,097. In the case of the large collections, is there not considerable subdivision?—When I speak of the Berlin Museum, I ought to explain that there are several museums at Berlin. The Zoological Museum now is an entirely distinct institution from the Museum of Anatomy and Comparative Anatomy. It is again distinct from the Museum of Mineralogy and Palæontology, and up to a very recent period there was even a distinct museum for entomology, but this has now been joined with the Zoological Museum. Then again the botanical establishment is entirely distinct and in quite a different part of the town.

10,098. Is that connected with the botanic garden?—Yes; in all the German Universities you will find that the Hortus Siccus is joined with the botanical

A. Günther, Esq.

15 March 1872.

gardens; in fact the Professor of Botany takes, as professor, charge of the botanical gardens, as well as of the collection of dried plants.

10,099. How are those collections in Germany generally administered?—They are always administered under one head, the provincial museums as well as the University museums. Speaking of the latter first, the professor of the University always takes charge of that museum which is particularly connected with his subject. The Professor of Zoology takes charge of the Zoological Museum, the Palæontologist of the Palæontological Museum, and so on. Then he may or may not have, according to the extent of the museum, a staff of assistants. In the smaller museums you will hardly find more than one or two assistants. In the Berlin Zoological Museum it has been found necessary to employ a greater number of assistants, assistants who are in this case specialists. There is a man of great reputation appointed for conchyliology; another for the collection of birds; a third for entomology; a fourth for the other lower animals. Those men have become specialists; and differ very much from the assistants in the smaller Universities. The director of the museum of a smaller University chooses out of the body of elder students a young man who takes the post not for the salary's sake, which is extremely small, but simply from a love of science, and in the hope of further developing his opportunities of studying his subject. This man is not a specialist, but he is as it were an assistant of all work; he has to look after all parts of the zoological collection, and I ascribe to this system of training the fact that you get in Germany a body of men who have not been specialists from the beginning, who are acquainted with general scientific principles, and with the management of a general collection, and therefore able afterwards to take higher positions in life than mere specialists. I may draw particular attention to this point, because I have found that in this country in some museums it has become the rule to appoint very young men and to put them at once into the charge of very large collections; in fact, training them to be specialists without allowing them time to become acquainted with the other parts of zoology or any other part of science.

10,100. By whom are those appointments made?—With regard to the university appointments, the professors, and consequently also the directors of the museum, are proposed by the Senate, and appointed by the Government.

10,101. Does the professor who directs his department of the collection apply the money granted for it?—Entirely. This goes even so far that one of these directors may sell specimens out of the collection if it is really to the advantage of the museum, and he applies the money to some other purposes of the institution; there is nobody to control him.

10,102. What have you to state with regard to the income of the Berlin museum?—That is extremely small. However, the Prussian Government has to support, besides the Berlin Museum, three or four other large institutions; and if you lump all the sums together it will make a very considerable sum.

10,103. Besides the maintenance when once they are established considerable sums, I presume, must have been expended in the acquisition of those collections?—I cannot positively state what the annual grants of money are but I know that sometime ago I was told by the Director of the Berlin Zoological Museum that he had annually for his collection a sum to spend equal to 1,500 thalers, that is about 220*l*., but the Government are generally ready on extraordinary occasions to give special grants for the acquisition of particular collections.

10,104. Besides that the Government sometimes fit out exploratory expeditions, do they not, which send home a large number of specimens of natural history?—That has been done once by the Austrian Government who have sent out the "Novara" expedition, accompanied by a complete staff of naturalists; and then again the Prussian Government sent out some time back an expedition round the world also with naturalists, but the result for the zoological museum has not been so great as was expected, because that expedition had more a political object than that of making scientific investigations.

10,105. Was Ehrenberg sent out by the Prussian Government to Africa in former days?—He received a grant from the Academy.

10,106. He brought home, did he not, a vast number of subjects for the anatomical and zoological collections?—I am not prepared to give the details of the grants of money, but I should have been of opinion that support had been given to him by the Academy as Professor Peters afterwards again received grants from the Academy, not sufficient to defray all the expenses of his expedition, but certainly contributing a great deal towards the expenses.

10,107. If I remember rightly, considerable contributions to those museums were sent home sometimes by diplomatic persons and representatives of the Prussian Government in distant countries, some of whom were naturalists; for instance, from Brazil and some other parts, but that was many years ago?—I am not aware of it. Many years ago there was Prince Max of Neuwied in Brazil and in North America, but this was an entirely private expedition; he formed a museum, but entirely for his own private purposes.

10,108. Is much done for the maintenance of the museums by way of exchanges of specimens?—The smaller museums exchange very often, whenever they have an opportunity of exchanging; of course, they never acquire duplicates, they get those duplicates only as presents, but they are always required to utilize them in the way of exchange. I should not look upon that as a very considerable means of increasing their collections.

10,109. Is it the case that the smaller local museums are aided by duplicates from those larger central collections?—Never. There is no connexion whatever between the various museums in Germany, except when occasionally an exchange takes place between them.

10,110. You mean that there is no grant of specimens from the one to the other?—No, never.

10,111. With regard to the instruction carried on in connexion with the museums, have you anything to inform the Commission?—The lectures are always given in immediate connexion with the museum, which forms, in fact, the basis of the lecture.

10,112. The Professor is the director of his particular department of the museum?—Yes.

10,113. And he gives lectures upon it?—Yes; in fact it is the duty of the Professor to give those lectures at certain intervals. At the University of Tubingen and others the Professor of Zoology generally gives a lecture every other term, and one on comparative anatomy alternately with that of zoology. The Professor of Geology gives a course of geological lectures in one term, in the next term one of palæontology, and in some cases where mineralogy is joined with it, in the third term he gives a lecture in mineralogy.

10,114. Is it found that the duty of giving lectures in connexion with the museum interferes with the professor's special duty in the management and government of the museum?—I have never heard any complaint about that. I must say that the two kinds of duties go very well together, because as teacher he knows perfectly well what specimens he has to acquire in preference for his collection, and as curator he takes very good care that those specimens are well kept, and are not too much sacrificed to the knife. Then, again, in almost every museum there is a students' room or a laboratory, that is to say, the professor supplies his students with subjects on which to make their dissections and examinations.

10,115. Have you considered whether it would be practicable or advisable to give lectures in the British Museum in connexion with the collections there?—Certainly; and it is a matter of great surprise to me

A. Günther, Esq.

15 March 1872

that the nation allows itself to be put to such great expense every year without deriving a particular benefit from it by having a regular course of lectures given there.

10,116. Who do you think would be the proper persons to deliver such lectures?—I should say the men in charge of the collections—for instance, the keepers.

10,117. But, without at all objecting to your views, I would ask whether it might not happen that a gentleman would be very well fitted to be a keeper of a department, and yet not have a talent for giving lectures?—Certainly, those cases may happen, but I should say, in the first instance, that in the appointment of a man regard should be paid to that consideration—that a man should be able to express his ideas before the general public. Then, again, I consider the lectures on Natural History not so extremely difficult. If a man has been working at one particular subject the whole of his lifetime, I should say that he ought to be able, with the help of specimens and diagrams, to explain that which he has been working at all the year round. Those are a very different kind of lectures from those given at the Royal Institution, for instance. In that respect I may also remark, that I think that at the British Museum three kinds of lectures should be given, namely, first, a regular course of elementary instruction to the students, such as is given at the Universities. For instance, in my own case I ought to be obliged to instruct those who are willing to engage in the study of reptiles and fishes.

10,118. In what mode would you instruct them, would you encourage them in the actual dissection of those animals?—Yes, certainly. There ought to be a students' room in which the students attending the lectures should have an opportunity of making the dissections and the examinations of those fish under the supervision of the person in charge of such a collection.

10,119. Will you be so good as to go on and mention the other kind of lectures which you would recommend?—The second kind of lectures is one intended to be of a more general nature, and for the general public, such as are given at the Royal Institution. The third kind of lectures I should rather consider to be demonstrations in the museum to the lower classes, as is now and then exceptionally done in the museum. I believe last year on 10 or 12 evenings the working men of a certain institution came to the museum, and the gentlemen in charge of a part of the collections went round with them, and explained to them in the galleries the objects. The first kind of lectures might be given by the persons in charge of the several collections; the second might be given by those who are particularly fitted for it; and the third might be given by the assistants.

10,120. Do you think that the second kind of lectures might be given by gentlemen who were not actually attached to the museum as keepers?—They may be given by the keepers, or they may be given by men not connected with the museum but particularly fitted for that task.

10,121. Are the assistants of whom you speak quite competent to give that instruction which is desirable for the working classes?—Whether the present class of men are competent I certainly should not venture to express an opinion, but I should say that no man should be appointed in the first instance who would not be qualified to do that.

10,122. Might not a great deal of that instruction consist in pointing out the specimens and naming them, and saying where they came from, and what was remarkable or peculiar about the objects?—Yes, certainly. That is what I mean should be given to the lower classes, or to whoever liked to attend, say on Saturday evenings.

10,123. And the assistants should, you think, be quite competent to do that?—They should be perfectly competent to do that.

10,124. Is there any provision in the new building of the museum which would supply space for pupils studying there?—I believe that the space set apart for that purpose is extremely limited.

10,125. (*Professor Smith.*) You would wish to have it larger?—The students' room certainly. It would not be desirable to have men coming to the museum who wanted to examine a certain set of birds or insects, and others who dissected fish preserved in spirit in the same room. Therefore I say there ought to be at least three or four separate rooms set apart for that. The requirements of students studying various classes of animals are very different.

10,126. Are there any lecture rooms set apart in the new buildings?—I understand that there is a very large lecture room set apart which would be very likely most adapted for the second class of lectures which I have mentioned, but I am not aware that lecture rooms are set apart for a smaller audience.

10,127. (*Chairman.*) And that would be desirable in your opinion?—It would be very desirable.

10,128. When the Natural History collections are removed from Bloomsbury, of course they will be separated from the library. Will any means be taken to supply natural history books for the museum at Kensington?—I hope that the Government will provide a certain sum of money for that purpose, because if no sufficient library were provided the work at the collections would be perfectly at a standstill. I should direct particular attention to one part of the present library in the British Museum, and that is the Banksian Library. The Banksian Library was given to the Trustees of the British Museum together with Sir Joseph Banks's collections. It was not given as a part of the library; and, therefore, when those collections go, the Banksian Library formed in connexion with and for those collections should go too.

10,129. Are you quite satisfied that it is expedient to retain those collections of plants in the Museum, rather than to place them at Kew, as you say is generally done abroad, in connexion with the botanic gardens?—I have not myself formed an opinion about this subject, it lies in another department. I could not venture an opinion about it.

10,130. Are the local museums in Germany usually arranged in a satisfactory manner?—All the museums in Germany are extremely well arranged; particularly great care is taken that all the specimens should be named and properly named. Of course you find still a greater or less number of specimens which are badly mounted and badly preserved. However those are mostly the relics of former times, and at present the greatest care is taken that the specimens should be most skilfully prepared.

10,131. You are not referring now, I presume, to the principal museums but to the local museums?—To all the museums.

10,132. Are there generally catalogues of those museums?—Only manuscript catalogues.

10,133. But are these open to consultation by the visitors?—I believe not, and this is the less necessary because in these museums almost everything is exhibited and properly labelled.

10,134. There is no catalogue I believe of the Great Museum of Natural History in Paris?—There are only partial catalogues printed. A catalogue of reptiles has been commenced, but it has never been completed.

10,135. Then the British Museum is in advance in that respect of some foreign museums, is it not?—The British Museum is far in advance of all other museums in respect of catalogues.

10,136. Will you favour the Commission with any information which you think material respecting the great Muséum d'Histoire Naturelle in Paris?—I think that in that museum the principle of utilizing a large museum for the purposes of instruction has been carried out most successfully, and most consistently. There the various heads of the departments have the

A. Günther, Esq.

15 March 1872.

duty of giving lectures on their particular branches. It was in those lectures that Cuvier himself attracted the students of almost the whole world to Paris. His lectures were always given in immediate connexion with and with immediate reference to his museum. At present I understand that those lectures are not very well attended, but I believe that the cause of it is that the very same men hold other appointments, for instance as Professors of the Sorbonne, or at the College de France, or at the Veterinary College, and as they deliver the same lectures which are or ought to be delivered in the Jardin des Plantes, of course all the students who would attend the Jardin des Plantes' lectures do not think it necessary to go to the Museum; they hear the very same lectures in their own institution.

10,137. A good deal would depend upon the nature of the subject, I presume, some subjects being more attractive than others?—In this respect it has been my experience that a great deal more depends on the lecturer himself than upon the subject.

10,138. You mean that he makes the subject attractive?—Yes; I have been present at the lectures of Johannes Muller of Berlin, on the development of worms, a subject certainly not attractive to the general public, and the lecture room was crowded from one end to the other, perhaps 150 or 200 people being present.

10,139. Those lectures in Paris are quite gratuitous, are they not?—Quite gratuitous; everybody can attend.

10,140. You are also acquainted with the great museum at Leyden?—Yes, I was there about 10 years ago for a short time, and knowing the Director well I became acquainted with the institution as I may say totally.

10,141. That is a very unequal collection, is it not, that is to say, it is much richer in some departments than in others?—Yes; it is particularly rich in the productions from the Dutch possessions, and also from Madagascar; and the present Director having paid particular attention to the study of birds, has formed a collection from the Dutch possessions perfectly unequalled by any other collection.

10,142. Was Temminck at Leyden?—Yes; up to the time of Temminck's death, the collection was a much more uniform and general collection than it is now. Temminck collected from all classes with equal energy, and from all countries.

10,143. Does the Dutch Government encourage the sending home of specimens from their colonies for their collections?—Much more so than any other government, the English Government certainly not excepted. The very large collection made by Dr. Bleeker was entirely brought together by Dutch officials placed in the various islands of the East India Archipelago. He was supplied by his government with even the spirits of wine, bottles, and all the other contrivances which were sent out to those men, and in this way he brought together immense collections.

10,144. What does our own Government do in that direction for the British Museum?—Nothing.

10,145. It is left merely to the goodwill of the commanders of expeditions, I presume, and of scientific men who are with expeditions to bring objects of natural history to the British Museum or not as they think fit?—Quite so. When I said nothing, I recollect now two exceptions which I must mention. In the first instance the Admiralty allowed a naturalist, Dr. Cunningham, to be attached to the expedition to the Maghellan Straits, and Dr. Cunningham brought home a very valuable collection, just showing what might be done if this practice were followed with other similar expeditions. Secondly, the Admiralty have also printed a code of instructions for naval officers to show them in what way specimens of natural history may be preserved; but this, I think, is all that has been done by the Government of late.

10,146. (*Professor Smith.*) Is that known as the Admiralty Manual of Scientific Inquiry?—I think it is contained in that. Proof sheets have been submitted to me lately, but they were loose proof sheets, and I could not ascertain to what handbook they belonged. I was only told that they were instructions of the Admiralty to their naval officers.

10,147. Do you find that the naval officers take advantage of those instructions and bring home any considerable number of subjects?—None whatever.

10,148. (*Chairman.*) Looking now to the local collections of scientific objects in this country, to what uses do you think that they could advantageously be applied?—I think that in the first instance the people in the neighbourhood would flock to those collections and visit them, to satisfy their curiosity, spending a part of their leisure time in them as places of amusement. Secondly, if a good curator be placed over such a local collection, that man will certainly endeavour to draw young men towards him in order to instruct them. In the third place, it will lead to the formation of local societies, and if the members of such local societies also do not derive particularly great benefit from their superficial connexion with natural history, still it cannot be denied that in some measure their views will be enlarged, and those individuals who really have some taste for natural history will find the means of getting elementary and systematic information, and will be guided in the further developing of their taste.

10,149. And might not that afford a motive for intelligent young men at leisure time to study in order to collect objects and to improve those museums?—It is a very great incentive for a young man to make collections, which is the first step in developing a knowledge of natural history.

10,150. Are there any other uses, do you think, to which they could be applied? I refer particularly to the instructing of pupils in even elementary schools and grammar schools, both primary and secondary schools, in the way that you mention is done in Germany?—Yes, certainly; I think that this could be done much better in that way than by means of a small collection to be attached to such a grammar school. I think it better that the collection should be separate, and therefore available for several schools in the same place; because there is nobody who would take good care of those small collections attached to schools.

10,151. And it would be more economical, would it not, inasmuch as it would be easier to collect one considerable collection than a number of small collections?—Those small collections are so very inexpensive, that I suppose the expense would be rather greater if you had a general museum.

10,152. But a more general collection would be more efficient?—Certainly.

10,153. You have already mentioned generally the nature of those collections, but still keeping in view this country particularly, of course there would be a collection of zoology and geology and palæontology and the simple minerals which could be got, and then ethnological and archæological objects?—Yes.

10,154. Do you think that in those provincial collections in this country means should be taken to provide a typical series of the different natural objects, and then to have more extensive collections illustrative of the natural history of the locality?—This would be the object of those local collections; first of all, they ought to have a complete collection of the objects occurring in the immediate vicinity, or at least in the British islands; and then they ought to have what is generally called a typical collection.

10,155. Supposing that there were any general organisation for those museums with reference to the importance of the locality, the amount of population, and the like, do you think that that typical series might be more or less detailed; in some cases it being enough probably to have a very few specimens to represent a typical series, and it being desirable in other cases to aim at greater fulness?—Besides the general principle that it

A. Günther, Esq.

15 March 1872.

should not become a very extensive collection, I should not lay down any other rule, but should leave it entirely to the curator to develope his collection as well as he can. If you tell such a man you must go so far and no further, he will simply cease to work, and take no interest in his collection.

10,156. Under what management do you think that those local museums ought to be placed in this country?—I think certainly they should be subject to a regular system of inspection, and if it is the intention to establish in the metropolis, as it were a mother institution, I think you could not do better than to employ the men of that institution as inspectors, because they have got the best practical knowledge which will enable them to find out whether a collection is well managed or mismanaged.

10,157. Might those inspectors be connected with the British Museum?—Certainly.

10,158. And to whom would they report upon the state of the local museums?—Of course there must be a general head. If there were such an institution as a ministry of instruction in England, the question could be very easily answered.

10,159. Under proper regulation do you think that the British Museum could aid those local museums by supplying duplicate specimens?—The British Museum could certainly aid those daughter institutions at the beginning, and also afterwards, from time to time, by giving them specimens; but if you would put it as a duty upon the British Museum to supply those institutions with a series of type examples, you would entirely change the character of the British Museum. Those duties would be so heavy that without having a double staff of men it could not be done. It is quite incredible how much time is taken up by the management of what are called duplicate specimens.

10,160. You mean in discriminating them?—In discriminating them, in putting them aside, in preserving them, in distributing them, and in carrying on a correspondence about them. At present in the British Museum (I can speak only in this respect of the collections under my charge) we have duplicates; that is to say, when we get collections presented there are certain specimens amongst them useless for us, which I do not embody into the collection, and I put them aside; but then I advocate that all those should be given away to any other museum from which we have received contributions, rather than that they should be utilized in the way of exchange, or that we should be made responsible for giving at the same time correct definitions of those specimens.

10,161. There is no doubt often a difficulty in determining what is a duplicate and what is not; but in a great many cases duplicates must be obvious?—There can be no doubt that if a man discovers a certain fish in one of the lochs of Scotland, and sends me all at once some 50 specimens of it, there are duplicates amongst them; but in many cases I may have 100 specimens of the same species and not one of them is a duplicate. To decide what is a duplicate is only possible to a man who studies a certain branch, and nothing is more dangerous than for a man not thoroughly acquainted with a certain part of the collection to select specimens therefrom as duplicates.

10,162. (*Sir J. P. Kay-Shuttleworth.*) But if you had connected with your own department, and so with the other departments of the British Museum, a staff of inspectors whose duty was not simply to visit local museums, but to ascertain what was wanting for the creation of typical collections, and likewise was in constant communication say with your department, and so with other departments, to ascertain what duplicates were available for the several collections in the country, greater facilities would be given both for ascertaining the local wants and for the distribution of such duplicates as had been ascertained to be such?—Certainly; only unfortunately what those local museums want are specimens which we generally do not get so very easily except when we purchase them. We do not get those specimens so freely that we could send away say only a dozen duplicate specimens of the same species. The specimens required for typical collections are always those most sought for by all large collections all over the world, and therefore they are rather scarce.

10,163. On the other hand, is there not under the present system, with the want of facilities for distribution, a considerable waste of duplicates for which there is no application?—Speaking entirely of my own branch, I think the few duplicate specimens are applied in the most perfect way. I do not mean in the country; I mean by giving them to other museums, at home, in the colonies, or abroad, which actually want them. The number of our duplicate specimens is extremely small, because I should consider myself a very bad curator if I were to purchase a single specimen which might turn out to be a duplicate. It is only occasionally when specimens come in as a present, that I have duplicates.

10,164. Are you aware whether that is the case, for example, with respect to the botanical collection at Kew, whether there is or there is not in the botanical collection at Kew a large opportunity for the distribution of duplicates?—A botanical collection is, in this respect, quite of a different character to a zoological collection. One man may collect a hundred flowers off one tree, and send them home to Kew quite ready for distribution; but a man who sends home zoological collections would not be able to send home a hundred birds of paradise at the same time.

10,165. On the other hand, if the Government were to place, either in the hands of the governors of colonies, or of commanders of stations of the navy, some fund for the purpose of promoting the collection of specimens of natural history for the museum, probably the number of duplicates at your disposal would be very greatly increased?—Yes, it would be; and so would our work be, for in receiving those specimens we should be obliged to stuff or prepare them for those local museums, because you cannot attach to each local museum a stuffer or an articulator. This would be too expensive.

10,166. But looking to the wants of the country as to education in natural science, and to the importance of the formation of typical collections in the country for the purposes of such education, either in secondary schools or in the colleges, would not the proper mode of creating such typical collections be that which I have previously hinted at, that the Government should use the organisation of the colonies and of the naval stations with sufficient funds as a means of collection, and should give you sufficient funds likewise for the preparation and distribution of those collections?—No doubt this plan would contribute generally towards the ends of science, but there would be another question, whether you would not find it in the end cheaper to have simply a list of the typical specimens wanted for those local museums to show them what they must have, and then to leave it to the ordinary dealers in natural history objects to get into the market a certain number of those specimens. You would find that with much less trouble to the officials, and with less expense, you would get a sufficient number of those specimens.

10,167. You think that the natural operation of supply, if the demand were created, would accomplish the result more easily than by such general governmental organisation?—Quite so. I do not speak here theoretically, but I speak here from experience. Whenever an animal has been found of particular interest, at once the agents in London take the necessary steps to get the necessary supplies of specimens. By the labours of Professor Owen and others, the attention had been drawn to the Monotremes of Australia, and I know that, in consequence, there came not less than 200 specimens of the Echidna to one shop in the east end of London, and 15 years ago, when I first came to London, there were a number of these specimens rotting in a yard of that shop.

A. Günther, Esq.

15 March 1872.

10,168. That would, however, involve that the local museums should have funds with which to purchase?—Yes, but that comes to the question of whether it would be better to give this fund to the governors of colonies and commanders, or whether you would give the money into the hands of the curators for the purpose of purchasing specimens.

10,169. (*Chairman.*) You would prefer the latter?—Yes, that would be the most economical in the end, and the most satisfactory to the curator besides. You make the curator responsible for getting good and useful specimens. A curator who is supplied with specimens, and exhibits a set of paid-for specimens will say, if the specimens are not good, I cannot help it, they were sent to me by the Governor at the Cape, or by the British Museum. He is not responsible for them, but if he has to buy the things himself, he will be responsible.

10,170. (*Sir J. P. Kay-Shuttleworth.*) So that in fact the way to create a supply would be to provide the curators of the several departments, first, with the funds to purchase and then with the means to distribute?—Just so.

10,171. (*Chairman.*) You mentioned, I think, that the late Professor Lichtenstein, the Professor of Zoology in Berlin, had a plan of exchanges which was found not to answer, what was his plan?—His plan was, with respect to all the specimens which he conceived were duplicates in his museum, that he had a list of the names of them printed with a price attached to each of the specimens, and those catalogues were sent to the various museums in Europe and America. Each museum then stated what specimens it required, and the specimens sent were sold to the museum. But this is only another way of exchange, because that money he applied to purchasing specimens required by his museum. The consequence of this system was, that specimens misnamed in the first instance were given away from the Berlin Museum, and one of them was for some time a unicum in the British Museum. There is always this danger joined with the incautious selection of duplicates.

10,172. Have you considered how those local museums might be maintained apart from the plan of supplying them from a central department; from what sources the funds for their maintenance should be procured?—I have not considered that subject before.

10,173. Would you consider it advisable, provided certain funds could be raised by local exertion, that the government should supplement those funds by a grant for the purpose of the maintenance of those museums, or the improvement of them?—Certainly, but I really cannot see why the English Government should not adopt exactly the same plan as is adopted in Germany, or in Scandinavia, or in Denmark, or in Switzerland, where all those institutions established for the education of the people are supported by the government. The money for their support, wherever it comes from, comes finally out of the same pockets, only in one way it is collected and distributed in a systematic and just manner, and in the other way it is gathered in a very irregular way.

10,174. (*Professor Smith.*) I think you mentioned that the number of the University museums in Germany was about 16?—Yes, I think so.

10,175. Could you give the Commission any idea of the number of provincial museums of which you said there were very many?—There are many; I did not state the number, because I was afraid I would not give an accurate number; I am quite sure that there are many local museums of whose existence I am unaware at present, but I will mention those that I know more particularly. There is one in Stuttgart, a very large museum, one at Mayence, Darmstadt, Ratisbon, and Frankfort.

10,176. (*Chairman.*) Does the one at Frankfort contain Rüppell's collection?—Yes; then there is one at Bamberg, Erfurt, Fulda, at Hamburg two, one at Bremen, a very large collection, particularly distinguished by its large collection of extremely well-preserved birds; those are the museums which I recollect or have seen myself, those of the other towns are chiefly University museums.

10,177. (*Professor Smith.*) I suppose in Germany there is no difficulty found in obtaining proper persons to be curators of those provincial and University museums?—None whatever; the supply exceeds the demand.

10,178. Do you suppose that in England the same would be the case as in Germany?—I am afraid you would have a very great number of candidates, but not a great number of well-qualified candidates.

10,179. You spoke, did you not, of the museum at Berlin being divided into a great number of different museums?—Yes.

10,180. Do you mean to say that there is no common director entrusted with the management of the whole museum?—No; everyone has to direct under the Minister of Instruction.

10,181. So that under the Minister of Instruction, the different departments of the museum are entirely independent?—Yes, entirely independent.

10,182. Will you give us your opinion of that plan of management of a museum, whether it is found to answer at Berlin, in the first place?—Yes, it certainly answers well there. If there is only one director independent of a board, who is entirely responsible for the condition and usefulness of his institution, he feels the responsibility of the place, and he knows perfectly well that he is open to the inspection of the whole scientific world, because these museums are constantly watched and visited by men understanding the management and the character of a museum. He is not hampered by all that machinery which would necessarily be called into action if he were in connexion with a board.

10,183. Do any inconveniences result from this independence of the different parts of the museum; has that been found to be so at all?—No; there exists a certain rivalry amongst the museums, which I think is most beneficial for their development.

10,184. (*Mr. Samuelson.*) Do not you think that to have this plan of direct reference to the minister, involves the necessity of high scientific qualifications on the part of the minister?—Yes, I do.

10,185. (*Professor Smith.*) You spoke of the great museum of natural history at Paris, and you spoke of the principle of sub-division, as being carried very far in that museum also, did you mean that all the different departments are under management entirely independent of one another?—Entirely independent of one another, but they are all in that case dependent upon one head.

10,186. There is a supreme director, is there not?—Yes, there is a supreme director (I forget his name) with a sub-director, who, at present, is Professor Milne-Edwards. As far as I am aware, at present, there is one Chair for Mammalia, and, I think, for Ornithology which is combined with it. Then there is a second Chair for Herpetology and Ichthyology, the occupant of which died only a short time ago. I believe there is a third Chair for the Articulata, and a fourth Chair for the Lower Animals, one of them being occupied by Professor Quatrefages. Professor Gervais has charge of collections of Comparative Anatomy and Palæontology.

10,187. Have those professors charge of particular parts of the collection?—They have charge of particular parts of the collection, they have to deliver lectures on those parts, and those professors are under one director.

10,188. (*Chairman.*) That is not the minister, I believe?—No, he is responsible to the minister.

10,189. (*Professor Smith.*) Is not that an entirely different principle from the principle upon which the University of Berlin is managed?—A different principle in this respect, that it approaches more the present organisation of the British Museum, where the Natural History Departments are under one superintendent, who is again responsible to the trustees.

10,190. I think you are of opinion that it would take a very long time, and would be a difficult task, to form even a tolerable natural science library?—

A. Günther, Esq.

15 March 1872

I should say that it cannot be done in less than 25 years, considering the great number of books of the last century and the beginning of the present, which are required as books of reference; they are books extremely scarce now.

10,191. At the British Museum at the present time you have everything you want in the way of a library, have you not?—With very few exceptions indeed.

10,192. When the museum is transferred to South Kensington, if the Banksian Library should be transferred as you suggested, would you then have nearly all that you required?—No, not by the Banksian Library alone, because the Banksian Library has been continued only up to the period of Sir Joseph Banks' death, and must be supplemented by the literature subsequent to that period.

10,193. And would that supplementing of the Banksian Library require a great outlay, and a considerable time?—It would require a great outlay, but very little time indeed.

10,194. You mean that the books that have been published since that time, can be had for a price?—Yes, they can be had, they are still in the market.

10,195. (*Chairman.*) Is there any other point on which you would like to inform the Commission, which has not been fully brought out?—There is only one point on which I should have liked to have expressed an opinion, and that is the abolishing of a separate Palæontological Department, thinking it entirely in accordance with the present state of science, not to separate extinct animals from living. Of course when a union of palæontology and zoology in a museum is attempted, it cannot be done in the way in which it has been proposed, namely, to unite palæontological, zoological, and anatomical collections, in the same rooms, I may say almost on the same shelves, but I think it would be extremely advantageous for the development of science, and for the development of that museum to place the various branches of zoology in their recent as well as their extinct forms under one head, that is to say, that whoever has charge of the recent mammalia, should have charge also of the fossil mammalia, and whoever has charge of the fossil shells should take the recent shells too. I am so fully convinced that this system would answer extremely well in a large collection, that I thought I must mention it before the Royal Commission. That a plan of uniting heterogeneous collections in the same locality cannot be carried out is perfectly evident, when you consider, for instance, what an immense collection of specimens preserved in spirits we have at present in the British Museum. These collections are preserved in a quantity of spirits, equal to something like 15,000 gallons of highly inflammable spirits of wine. I think it is an extremely risky thing to keep such a collection in close union with other collections, or even in the same building, and I think it absolutely necessary to have a separate place for collections of that kind, in order to obviate any danger to the general collections. But if this plan be adopted, then of course the plan of uniting various collections in the same localities falls also to the ground, because a very essential part of the zoological collection is eliminated.

10,196. In that case, supposing that you were studying the Echinoderms, and part of the specimens were dry and others were in spirits, one part would be in one locality in the museum and the other in a different one?—Yes, certainly; but that is not in the least a practical disadvantage, because if a man comes and wants to study a certain group of Echinoderms, he has nothing to do but to give notice to the person in charge of the Echinoderms, and this man has to produce in one and the same working room the specimens, dried as well as in spirits, required by the student.

10,197. So that you would bring the two things together in the working room, though not upon the shelves?—No, not in the general collection. The same is the case with the collection of fish. Although the majority of the reptiles and fish are preserved in spirits, still a very great number of them are preserved in a dried state.

10,198. And you would have them in different localities for the sake of safety?—Precisely. Then again, it would be almost impossible to bring specimens of lizards preserved in spirits, others in a fossil state, and again stuffed specimens and skeletons together into the same room; practically it cannot be carried out.

10,199. Then, I suppose, the Commission will understand that when you express an opinion in favour of connecting the palæontology with the particular division of recent zoology to which it belongs, it has nothing to do with the locality?—No, merely the direction or administration.

10,200. (*Sir J. P. Kay-Shuttleworth.*) Have you considered the risk which you have described as arising from the great store of spirits of wine which is at present necessarily kept in the museum for the preservation of wet specimens, to be so great as to require their complete separation from the dry specimens, for the safety of the museum?—I do most decidedly, and I have held that opinion ever since I have become connected with a collection of wet specimens.

10,201. I understood you to say that you consider that the impediment to study might be overcome by collections of the wet and the dried specimens being brought into the working rooms for the use of students?—Quite so. It may be entirely overcome in that manner.

The witness withdrew.

6, Old Palace Yard, Westminster, Wednesday, 17th April 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., Sec. R. S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

C. WYVILLE THOMSON, ESQ., LL.D., F.R.S., examined.

C. W. Thomson, Esq. LL.D., F.R.S.

17 April 1872

10,202. (*Chairman.*) Will you be so good as to state to the Commission in the first place what is the professorship which you hold in the University of Edinburgh?—The Regius Professorship of Natural History.

10,203. The Commission will be glad to hear any evidence which you can supply them with as to the amount and kind of instruction which is given in Natural Science in the University of Edinburgh?—I was appointed Professor in the beginning of last year, and last year I delivered a course of lectures during the months of May, June, and July, to a class of 210 regularly entered medical students, besides a few voluntary students. In the winter I delivered

C. W. Thomson, Esq., *LL D., F.R.S.*

17 April 1872.

another course of lectures to between 30 and 40 medical students likewise. Up to the present time that is the only instruction by lecture which has been given by me. During the next session, from May to the end of July, I again teach a large class of medical students, and I have a practical laboratory which has been constructed during the last winter, and there I shall teach a practical class, limited to about 20 students, in zoology, with the assistance of a regular assistant, Dr. Charles, who is well capable of conducting practical instruction.

10,204. Are your lectures entirely confined to the subject of zoology?—Yes, to zoology entirely, recent and fossil, with physical geography so far as it is required to illustrate the distribution of animals and palæontology.

10,205. Does the University possess suitable buildings for the department of teaching in which you are engaged?—By no means. I have been obliged to teach in the chemistry class room, which is a matter of great inconvenience. The regular natural history class room is seated for about 80, and the class amounted last year frequently to upwards of 250. There is a greater want of additional accommodation possibly in the natural history department than in any other. The practical laboratory will possibly accommodate 20, but it will not accommodate more.

10,206. Is there any probability of the University being able to supply you with better accommodation?—I should think so. Evidence has been already laid before the Commission as to the want of accommodation in all the practical departments, and it is so extremely pressing that we have now determined to commence the enlargement of the buildings, or the building of a new medical school. I hoped to have been able on this occasion to say that we had already procured the ground for a new school, but there has been some little delay; but we hope that very shortly arrangements will be made for the new building.

10,207. We shall be glad to hear any evidence as to the reasons which induced the University to dispose of the museum, and then we shall be glad to hear any complaints that you have to make on the present system, as interfering with the general teaching in your department?—I do not know whether it would be proper to give evidence as to the condition of the museum before it was handed over from the University, because the history of the museum, probably, in that sense, is of importance. The questions of the condition of the museum and the sources of various collections, were gone into very carefully before the Scotch Universities Commission about the year 1830, and I have jotted down one or two notes showing what the position of the museum was at that time, and perhaps I might be allowed to quote a few of those statements. In the Appendix to the Report of the Commission it is stated:—"On the appointment of Professor Jameson to the Chair of Natural History in 1804, the museum was so inconsiderable that the whole of the articles were contained in a few cases, the collection of Dr. Walker, the preceding Professor, which contained many interesting objects, having, upon his death, been removed from the College by his trustees. The specimens were of birds, serpents, minerals, and dresses and weapons of savage nations. The birds were in so decayed a state that they were soon thrown out. Professor Jameson substituted his own collection, and added to it, by all the means which he could employ and by the funds which he possessed, from 1804 to 1819. Upon application to the Town Council, a spacious and handsome museum was fitted up. During the period mentioned the museum was enriched by the minerals and books (the latter of which have since been placed in the College Library) left to the University by Doctor Thomson of Palermo, and by the collection of the celebrated Dr. Hutton of Edinburgh. In the year 1807, at the suggestion of the Professor, an application was made to the King for permission to have circulated, from the different public offices, printed instructions for collecting objects of natural history for the museum, and in consequence of this being granted vast additions were made to it. It became necessary to have additional accommodation, and as the College buildings were proceeding, orders were given for speedily finishing the splendid halls and galleries of the new museum. While it was fitting up, the intersecting collection of Dufrésne, which had been offered to sale at Paris, was, upon its value being ascertained, purchased by the Professors. Several valuable articles were about the same period purchased by them at the sale of the cabinet of the late Mr. Bullock. All these collections, and those contained in the first and second museums, were brought together and arranged in the museum of the new College in the year 1820. Since that time the collection has increased more than at any former period, so that it is nearly double what it was in 1820. A new series of five rooms has been added, and these being now nearly filled with beautiful and interesting objects of natural history, still further accommodation alone is wanting to render the Edinburgh museum in a few years equal in extent and splendour to some of the most distinguished museums in other parts of the world."

10,208. Is that a description of the museum as it is now?—No, as it was while it was in the possession of the College, about the year 1830. This is taken from the Report of the Commissioners. There is another point to which I would refer in the same Report. "We also applied for and obtained from the Colonial Office a copy of the application made in 1807, to which reference has been made, and of the answer made thereto by the Government. These papers, consisting of a memorial of the Lord Provost and the Principal of the University of Edinburgh, presented to Lord Castlereagh, and of his lordship's answer, form part of the same appendix, in which is also included a copy of a letter from the Admiralty Office respecting the transmission of a collection of articles from Paris. We have to observe that after a perusal of these papers, no doubt can remain that the articles imported under the facilities and immunities afforded by Government are absolutely public property. The request and the answer both specify that 'the objects are to continue in all future time the public property of the University, under the charge of the Regius Professor.'" I simply read that to show the position of the museum and its condition at that time.

10,209. Do those words, "public property of the University," mean anything different from the property of the University?—I think it is intended that it is to be public property, that it is to be the property of the community. There is another quotation from the general report of the Commission which I would like to read: "But whatever causes may have led to such contributions" (those were contributions from the students of Professor Jameson and others), "we apprehend that when the articles were imported in virtue of the privileges and exemptions granted for the purposes, and on the applications already mentioned, they became necessarily part of the public collection, and could not have been introduced into the country upon any other footing, the condition being, as originally expressed in Lord Londonderry's letter of the 14th May 1807, and renewed in all subsequent exemptions or licenses granted by the Government officers, which objects are to continue in all future time the public property of the University under the Regius Professor." That sentence is quoted more than once.

10,210. (*Dr. Sharpey.*) It would seem to be intended to distinguish them from private donations presented by old pupils to the Professor?—Yes, perfectly so.

10,211. (*Chairman.*) I propose now to ask you at what time the museum was transferred to the Science and Art Department, unless there is anything you wish to mention previously?—I do not think there is any point before that, with the exception of the purchase of those different collections, such as the

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

Dufrésne collection, which was an extremely valuable one, a large collection of birds; and the bequest of the collection of Dr. Hutton, which was very remarkable on account of its being a collection illustrating his views on geology, and the great controversy which was raging at the time between the Huttonians and the Wernerians. The collection of Dr. Thomson at Palermo was an extremely valuable one also, being a collection of Vesuvian minerals. There is one other document which I should wish to refer to. There was some difficulty in determining what was the condition of the museum just at the time of the transfer from the University to the Science and Art Department, and I find a memorial from the Lord Provost, Magistrates, and Council of the city of Edinburgh to the Right Honourable the Lords Commissioners of Her Majesty's Treasury, in which there is a statement of the various articles which had accumulated in the vaults of the museum, and which there was not space at that time to show. There is a list of those objects,—first, "nearly the whole of the great geological-geographical collection, consisting of upwards of 22,000 specimens," was a collection of rocks which Professor Jameson, who, at that time, took the Wernerian side in the controversy, had collected, in support of his views, from all parts of the world.

10,212. What is the date of that paper? — This is dated the 16th March 1852, shortly before the transfer to the Science and Art Department. It is from information by Professor Jameson himself, and it is written by Mr. Duncan McLaren, now Member of Parliament for Edinburgh, who was then Lord Provost. "2. About 4,000 specimens of the mineralogical collection. 3. About 10,000 specimens of organic remains. 4. A valuable collection of rare quadrupeds, many of them of the larger and most important species, which cannot be prepared for want of room. 5. A collection of 4,200 birds. 6. A collection of 500 fishes and 40 reptiles. 7. A collection of nearly 800 skeletons and crania of mammals, birds, reptiles, and fishes. 8. A collection of 500 invertebrate animals. 9. A collection of 3,000 specimens of recent shells, so important for practical geology. 10. Besides the above, there are many interesting collections made during the voyages of Captain Ross, Captain Parry, Lord Byron, Sir John Richardson, Captain Scoresby, and Captain Fitzroy, presented to the museum by the Lords of the Admiralty, none of which are at present accessible to the public, or even to the scientific inquirer, solely from the want of room to exhibit them." The transfer was finally made about the year 1854, or, at all events, arrangements were made for the transfer.

10,213. Do you know what induced the University to agree to the transfer?—About that time the museum had been founded at Stephen's Green in Dublin, and the museum in Jermyn Street was started not very long before, and there was a wish in Edinburgh that there should be a public museum of the same kind there. The idea of the Department of Science and Art at the time was to have the three institutions modelled pretty much upon the same plan—technological museums. Probably there was some difficulty in starting a museum of the kind, and Dr. Lyon Playfair, who took a great interest in the matter, urged the University to hand over their museum as a *nucleus* for a general public museum; there was also the building of the new museum, the best and most convenient site for which was directly behind the University buildings, and the windows of the University museum were blocked up by the new building, so that the light was shut out from the University museum, and that gave an additional reason for handing the collection over.

10,214. Did the University hand it over to the Department gratuitously? — The Town Council of Edinburgh, who were at that time the Patrons of the University, handed over the collection gratuitously. I have here the short correspondence on that subject. First there was a letter from Dr. Lyon Playfair, sketching the conditions under which the museum was to be handed over. This letter is printed in the evidence of the Commission on the Science and Art Department in Ireland. That Commission went to Edinburgh, and took some evidence in Edinburgh, and Mr. Archer, the present Superintendent of the museum in Scotland, handed in this letter. I think possibly the latter part of it may be sufficient for me to read. In the first place it states that certain bodies sent memorials for a new museum. The Senatus Academicus of Edinburgh University, the Royal College of Physicians, the Royal College of Surgeons, the Royal Society, the Royal Physical Society, the Society of Arts, and the Lord Provost and Magistrates of Edinburgh; and then, after speaking generally of the importance of the new museum and of the site, he goes on to sketch the general plan:—"My Lords, in the first place, submit that should Parliament in a future year vote money for building a museum on the site purchased, that such museum should be placed under the Board of Trade, in the same manner as the corresponding institutions in London and Dublin. The principles upon which these museums are conducted recognise the importance of using the specimens in them for instructional purposes to the fullest extent compatible with their security and preservation, and the same principles would be applied to the Scottish museum. Although, therefore, the University authorities, in order to prevent a divided responsibility, would have no controlling power in the management of the museum, my Lords would consider that its collections were used with great advantage to the public if they could be made available for the illustration of the courses of the Professors. Under these circumstances, it is submitted that it would be advisable that the University authorities should transfer their present collections to Government without any further conditions than those applied in the instructional use above referred to. These collections have, in fact, been chiefly made by parliamentary grants, an annual vote for their increase being taken. The Professor of Natural History has hitherto had a Crown appointment as 'Keeper of the Museum of Natural History,' and my Lords think that it will be advantageous that he should retain this appointment, but be responsible to this Board for its exercise. Although my Lords consider that he should be chiefly responsible for the arrangement, custody, and purchase of objects of natural history in the new museum, his duties in this respect should not be allowed to interfere with the due responsibility to Government of any general director of the museum who may hereafter be appointed. The possession of the University collections will secure to the new museum, in one institution, and with one expense of management, the combined advantages of the Industrial Museum in Dublin and of the Museum of the Royal Dublin Society, and will enable technological collections to be studied with great benefit in their primary relations to the scientific specimens of natural history. While the present Keeper and the amount of parliamentary grant now given will suffice for the extension and proper care of the natural history part of the museum, including the valuable collections of minerals and ores in the possession of the University, it will be necessary to develope much more extensively the collections in relation to the industrial arts. From the experience of the museums in London and Dublin, it is probable that the annual cost of the museum, when built, including both the scientific and technical divisions, will be about 2,000*l*. This includes the salary of a director of the museum at 300*l*., the sum given to Sir Henry De la Beche and Sir Robert Kane for similar duties that also of a chemist to analyze the specimens of ores, soils, and other industrial products." I think those are all the points specially bearing upon that subject in that letter of the 20th July 1854.

10,215. (*Professor Huxley.*) According to that document, the evident intention was that the Uni-

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

versity, as an university, should have no power of control whatever over the museum?—Precisely so.

10,216. But there is a provision for the Regius Professor, as Keeper, who is, to a certain extent, paid by the Department of Science and Art, is he not?—He is paid 100*l*. a year by the Department of Science and Art.

10,217. On the ground of being Keeper of the collection?—Yes.

10,218. There is a provision for his having power to regulate the arrangement, purchase, and so on, of these specimens, so that, while the University is excluded from interference, the Professor, as Keeper of the collection, has a power of interference?—He has a power of interference, certainly, according to the views in this letter.

10,219. What I mean is, that the phrase excluding the University from interference, does not in the least degree militate against the exertion of the power of the Keeper as Professor?—Certainly not. I understand the intention of this letter to be that the Keeper was to have the control of the collection, but to be ultimately responsible to a general director in case of a general director being appointed. On the 20th of July, the following letter was written by Dr. Lyon Playfair: "Sir, I am directed by the Lords of the "Committee of Privy Council for Trade to enclose, "for your Lordships' information, a copy of the esti-"mates of the Department of Science and Art for the "present year; and I am to draw your attention to "the fact that Parliament has voted a sum of money "to purchase a site for a new museum to be built "behind the present buildings of the University of "Edinburgh. At page 15 of the estimates your "Lordships will find a letter in which the views of "my Lords in regard to the proposed museum are "explained." That is Dr. Lyon Playfair's letter which I have just read. In this letter it is stated that "one of the officers of the Department ascer-"tained from your Lordships that there would be "no unwillingness on the part of the authorities "in Edinburgh to transfer to the Government any "rights that they may have in the University Mu-"seum, on condition that the new National Museum "was made fully available to the Professors of the "University for instructional purposes. It was also "stated that the site contiguous to Mr. Alexander's "chapel, and now belonging to the University, would "be given gratuitously to the Government as an "addition to the site about to be purchased under the "vote referred to. I am to request your Lordships to "bring this subject under the notice of the Town "Council, and should that body approve of the arrange-"ments proposed, it would be advisable that it should, "by a resolution placed upon its minutes, decide "that the site now the property of the University "should be legally conveyed to the Government, and "that any right that the Town Council may have in "the property of the museum should be conveyed in "like manner." This is from Dr. Lyon Playfair to the Lord Provost of Edinburgh. It was read at one of the meetings of the Town Council, and on its being read the following minute of the Town Council was passed. This is the minute which actually conveys the museum to the Department of Science and Art: "The Magistrates and Council, taking into "consideration the views of the Lords of the Com-"mittee of Privy Council for Trade regarding the "formation in Edinburgh of an industrial museum for "Scotland, to be opened to the public free of charge "during certain days of the week, as explained in the "letters before referred to, on the Report of the College "Council, and in furtherance of the proposed esta-"blishment, did and hereby do renounce all right of "property in the management of or control over the "collections forming the Museum of Natural History "in the University of this city, belonging to them as "patrons and guardians of the said University, to and "in favour of the Lords of the Committee of Privy "Council for Trade, and they did and hereby do "bind and oblige themselves and their successors in "office to transfer all such rights to their Lordships, "and also all right, title, and interest which they "have or can have as patrons and guardians afore-"said in or to the area of land in West College Street, "bounded by the said street on the east, the grounds "of the Trades' Maiden Hospital on the west," and so on, "Declaring hereby that such renunciation and "transfer as aforesaid are and shall be made on the "condition that the views of the Lords of the Com-"mittee of Privy Council for Trade expressed in the "documents before referred to shall be fully carried "into execution by the said Lords." There was no Act of Parliament, but the transfer is referred to in the Edinburgh Land Act, which is the 18th and 19th of Victoria, but merely in the recital. I think those are all the documents which bear immediately on the transfer of the museum to the Department.

10,220. (*Chairman.*) The material point for us to inquire into is whether the arrangement has worked well as far as the teaching of the University is concerned?—I certainly would not say that it has worked well. I must explain that I have only been appointed comparatively lately to the Professorship in the University, and since I was appointed I have interfered very little, scarcely at all, in fact, with the museum. I went to the museum on several occasions and talked over a variety of matters with Mr. Archer, and I found that the arrangements were such, and that there were so many inconveniences connected with them, that it was necessary before going regularly to work that the whole thing should be cleared up. I therefore represented to the Science and Art Department, through Mr. Cole, what I considered to be the disadvantages of the present arrangement, and in fact I declined working regularly, or doing anything further than what was necessary in order to prevent a lock, until some definite arrangement had been made. At my appointment to the Chair the Minutes of the Committee of Council on Education at South Kensington were revised, and certain changes were made in them. I may mention, however, that at first the present Director of the museum, Mr. Archer, was appointed Superintendent; and at the time when he was appointed Superintendent it was distinctly understood, as far as I am aware, that the scientific management of the collection was to be under the scientific officer, that is to say, the Natural History Department was to be entirely under the control of the Keeper. At the time that Mr. Archer was appointed Superintendent, the collection was still in the College buildings, and the Keeper in fact had the entire control of the collection, as he had previously had from the beginning. Professor Jameson actually made the collection, and he was Regius Keeper, and from that time onward the collection had been entirely in the charge of the Keeper. About the year 1864, the Natural History collection was removed to the new building, and about that time, by some means which I do not exactly understand, Mr. Archer, who at first had been Superintendent, became Director, and then certain technical points came into play, for instance, that one with regard to the duties of the Keeper not interfering in any way with the absolute undivided responsibility of the Director. Under a technical interpretation of this clause in Dr. Lyon Playfair's letter, Mr. Archer took the entire charge of the Natural History collection, and from certain circumstances it became absolutely impossible for the Keeper to exercise any control whatever over the Natural History collection.

10,221. In your capacity as Professor of Natural History, you find decided inconveniences and evils arise from the present arrangement?—Most decidedly; but I do not think that there should be any difficulty whatever in making an arrangement which would work tolerably well.

10,222. You do not think that there is any inherent or necessary difficulty in the museum belonging to the Science and Art Department, and at the same time being rendered useful as an instrument of University teaching?—That is rather a wide question. I do not

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

think that the Department of Science and Art, as it is at present constituted, has any machinery for working the Natural History Museum in Edinburgh. I may mention, in connexion with this, that not long ago I was summoned to London to confer with the Lords of the Privy Council on this matter. I wrote beforehand to Mr. Cole to say that I thought it would be most important, if we were to have a conference which was to lead to anything, that there should be some naturalist or some scientific man present; but when I came to town I found that the Lord President of the Council, Mr. Forster, Mr. Cole, Captain Donnelly, and Mr. Archer only were present at the conference; and none of them being specially men of science, it was quite impossible to discuss the question in a satisfactory way. In fact it was impossible for a board so constituted to understand the bearings of such a question. I think that if our scientific museums are to be in the hands of the Department, it would certainly be most important that there should be a Scientific Council, in whom the public, and the scientific men who are connected with the various institutions under its control, would have perfect confidence, to whom the Department could refer, and to whom it could refer publicly and certainly, instead of taking mere haphazard opinions from one scientific man and another. If there were a board of reference of that kind in connexion with the Science and Art Department, I do not see that there would be the smallest disadvantage in such institutions being under the Science and Art Department, under the Crown, and I think that the museum in Edinburgh would work perfectly well; but such a board would at once see where the difficulties are, and would know from experience and knowledge of such matters how the difficulties could be remedied.

10,223. Are you prepared to suggest any scheme which you think would meet the evils of which you complain?—As matters stand at present in Edinburgh, I think it could be very easily done, and made to work quite well. There are two distinct departments, one of them an industrial and general public museum, the other a strictly scientific museum. As the latter is the only museum which we have in Edinburgh for teaching and for reference, there should at least be a distinct scientific department connected with it. I think that there should be a competent assistant in the museum, and that this assistant should take his directions, so far as the scientific arrangement of the collection is concerned, from the Regius Keeper. If that were the case, there would be really no further difficulty. The general Superintendent, or whatever he may be called, of the museum, should have the general management and the general administration of the museum, and see that everything is kept clean and in thorough order, and he should also have instructions to report at once if anything is wrong, to see to the hours of attendance of the assistants in all the departments, to the arrangement of the servants, and so on; and if he saw anything in the conduct or management of the Regius Keeper which he thought unsatisfactory, I think he should be instructed at once to report to the Department. I think, however, that the scientific part of the museum ought to be under a special first-class assistant, who should receive his instructions in all scientific matters from the Keeper.

10,223*a*. That would be, in fact, a re-transferring of the scientific collection to the University again, would it not?—I do not think that that was ever intended.

10,224. In what would it differ from that?—I believe it would simply be a safe and reasonable mode of administering the collection under the Department. The property of the collection would still be vested in the Department.

10,225. But it would be solely used for University purposes?—No, certainly not. I look upon the University use of the museum as a very important one, but as exceedingly subordinate, in fact, to the general public use; but I think that the Professor of Natural History in the University, who is the Regius Keeper of the collection, probably would, better than anyone else, be able to manage the scientific part of the museum, so as to make it popularly useful. In fact, I would look upon that part which could be used as a special collection for general popular instruction as the most important part of the museum. I may mention that the Free Museum in Liverpool is arranged in such a way that it would be quite as useful for University purposes as for the purposes of popular instruction.

10,226. Is the Liverpool museum used for teaching purposes?—I think it is a little, but it is connected with no University.

10,227. (*Dr. Sharpey.*) I understand you to propose that there should be an Assistant Keeper in constant charge of the scientific department, and that all the scientific arrangement of the Natural History specimens should be conducted by him under the direction of the Professor?—I do think so.

10,228. And that the Professor should have full command of obtaining the specimens when he required them for his class?—Yes.

10,229. Do you find any difficulty at present in obtaining the specimens you require for the illustration of your lectures?—I do not think that I should find any difficulty; if I were to go to the museum daily and look out the specimens, I am perfectly sure they would be given at once; but in order to avoid any personal question arising at present, I have adopted the plan of sending my assistant to the museum, and getting a general series for illustrating different parts of the course. That has not been a very satisfactory course, but I have adopted it more to prevent any personal clashing until the question was finally settled, than anything else.

10,230. Do you consider that you have really free command over those specimens, to use them as you think fit, consistently with their safety, for your class illustration?—I should think that I could get any specimens that I wanted which could be removed with safety; I think probably at present I could do so.

10,231. In what does the present evil consist?—The present evil principally consists in the Professor not having the control of the classification, or the selection of the specimens. I believe that one of the most important parts of instruction in the subject would be taking students to the museum and grinding them from the specimens themselves in the museum, without removing the specimens to the lecture room; but that, under the present system, the Professor cannot do, because the specimens are neither named nor arranged in a satisfactory way. Then another inconvenience is, that, under the present system, there is no one with the control and management of the museum who has any idea of the mode of preserving specimens, keeping specimens in spirits, and so on. All those points ought to be under the management of some one who understands them, and owing to the want of some one who understands such things, and who is responsible for carrying them out properly in the museum, and seeing to the preservation of objects, it certainly would be quite absurd at this moment to add to the museum valuable specimens which require care. The spirit specimens which are in the museum now are many of them becoming destroyed and lost on account of their not being properly mounted and looked after, and additions could not safely be made until some arrangement is come to. Then there is another thing, and on this point, perhaps, I ought to quote from a letter which Mr. Archer wrote to me on the subject, which will show clearly what he supposes his rights to be, and how completely they clash with those of the Keeper. I have also my letter. I do not know whether the Commission would wish to hear both letters. It is merely to show the view held by the Superintendent. I have avoided as far as possible all controversy in this matter, but this merely shows how the present plan locks.

10,232. (*Chairman.*) Does he consider that he is not the head of a scientific institution in any way, and that the object of the museum is not for scientific purposes?—In his evidence before the Commission on

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

the Science and Art Department in Ireland, he gives an extraordinary view, at least it was extraordinary to us, as to the objects of this museum.

10,233. If they are diametrically opposite views, if the one party considers that it is not a scientific museum in any respect, and the other regards it as intended for scientific purposes, it is not likely that they can work satisfactorily?—I may just mention what he says here. This letter arose from his writing to me, asking me to send him a form of application for everything which I required for the class. I had not done so up to that time, and I believe my predecessor had declined doing it. I wrote to him to say that I had no objection whatever to fill up such a form, but that I would suggest that to put the thing on a proper footing and avoid reflections in future, no object should be removed from the Natural History Galleries by himself or myself, or by my assistant, for any purpose whatever, without such a form as that which I employed being filled up. I wished him also to be bound not to remove things from the cases. I was responsible as Keeper of the collection, and I thought that that was only reasonable. He says, "With regard to the "suggestion in the last portion of your letter, I am sure "it is made in good part, but as the Department has "confided the arrangement, and display or withdrawal "of specimens to me, as Director, I cannot agree to it." It is perfectly evident that I, as the Scientific Keeper, cannot manage a museum from which anyone has the power of withdrawing specimens. I may mention that a very large number of specimens have been in this way withdrawn, no doubt perfectly in good faith on Mr. Archer's part, but from his taking views of the value of things very different from those which would be taken by me.

10,234. (*Dr. Sharpey.*) Do you think that under the present management there is sufficient security for completing and extending the series of specimens of particular divisions of Natural History, such as might be required for the purposes of instruction and reference, seeing that it often happens that those perhaps are the least conspicuous and the least attractive to the outside public?—I think there is an absolute provision that such series shall not be completed under the present system.

10,235. The collections of invertebrates and many of those series which are very essential for the purposes of instruction, may be considered, perhaps, of less moment by a non-scientific Director?—Most certainly; in fact Mr. Archer has again and again told me that he considered the main object of the collection to be to afford, I do not know whether instruction or amusement, to uneducated people, and to induce them to spend their evenings in the museum rather than in public-houses, and that that was the main object of the museum as it stands at present, and not a scientific object. No doubt it is a valuable object, but it must be remembered that the only scientific collection, a collection which corresponds with the British Museum, in London, the only scientific collection which we have in Edinburgh for reference has been transferred to this museum. There is scarcely a meeting of the Royal Society at which I have not complaints, because as Regius Keeper of the collection I am considered responsible. Of course I practically am not, for I can do nothing whatever under the present arrangement; but only at the last meeting of the Royal Society there were very serious complaints made that collections illustrating certain important points in fossil botany were incomplete, and unnecessarily so, from the materials which we had at hand; in fact that there was no collection for reference in the museum. Of course a year or two would put that all right, but at present it is most unsatisfactory. In fact I am at liberty to mention this:—A few days ago, before I left Edinburgh, a gentleman, who has an exceedingly valuable collection of the minerals of Scotland, told me that he had left his collection to the museum, and he asked me, as he had heard some curious things about the management of the museum, whether I thought he was justified in doing so. I certainly could not recommend him to do so, and I told him that he must take some means of providing for the safety of these specimens, because if they were added to the collection, and if one or two of the same name as specimens which are at present in the collection were added, they would certainly be sent away as duplicates, without reference to possibly very important distinctions of form, of crystallization, or composition, or the circumstances under which they were found; they would simply be sold as duplicates of a particular species of mineral.

10,236. Are you aware from what sources the income of the Director is derived?—The Director or Superintendent is paid a certain fixed salary, and also, I understand, a proportion of the general receipts of the institution paid at the door for admission, and also from some other sources, as, for instance, any conversaziones or anything of that kind. I have been informed that such is the case.

10,237. Presuming that the direction of the museum still remains as it is, have you sufficiently explained what, under such a condition, you consider the best arrangements to enable the Professor of Natural History to have the proper use of it, and for its being made available for scientific objects?—May I ask whether you refer to the contingency of its remaining under precisely the same kind of management, with regard to the management at head quarters for instance; because I think it is really a most fundamental point having some distinct scientific referees. I do not think it is possible to work a Natural History or Scientific Museum in Edinburgh with the present central administration.

10,238. (*Sir J. P. Kay-Shuttleworth.*) You think that the Education Department should not attempt to regulate scientific institutions unless it contains either scientific members or is assisted by a Scientific Council?—I do think so.

10,239. (*Dr. Sharpey.*) You suggested, did you not, an Assistant Keeper, who should have certain duties assigned to him?—Yes; I think he should be very much in the position of an Assistant Keeper in the British Museum, with probably the same emolument. I may mention that one of the assistants in the museum died lately, and that there is a vacancy in the post of Natural History Assistant in Edinburgh at present. I think that the salary attached to that office should be considerably increased, so as to make the situation a desirable one, one fit for a man who is sufficiently qualified; and that he should be appointed Assistant Keeper. He should have his general instructions with regard to the classification and to the scientific management of the collection, the mounting, the selection of objects to be mounted, the selection of objects for illustrating different groups, directly from the Keeper, who is an officer under the Science and Art Department, in his capacity of Keeper, not as Professor in the University. I think that the powers of the Superintendent with regard to the Natural History collection should be restricted to general administration.

10,240. (*Sir J. P. Kay-Shuttleworth.*) Your present objection is that there is a want of scientific appreciation, first in the collection of specimens, then in the selection of them, then in the exchange, then in their mode of preservation, and then in the general classification of the museum?—Yes; the Superintendent should not be allowed to interfere with the collection itself, except by the direction of the Keeper. I think that if anyone who is not scientifically acquainted with these matters, anyone who has not had a special training, interferes, or is at liberty to interfere, when he pleases, it is impossible that the collection can be satisfactorily managed. It is possible that a Scientific Director might have technically a right to interfere, a right which he would at once understand he was only to exercise on emergency.

10,241. (*Dr. Sharpey.*) Perhaps you would define what you exactly mean by interference?—Removing specimens, purchasing, exchanging, throwing out

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

specimens, or altering in any way the classification. Of course in all these cases there are exceptions. If a specimen were attacked with moth, of course the Superintendent ought to remove it himself, or take means that it should be removed, as he is responsible for the actual safety of the collection.

10,242. (*Professor Huxley.*) Who has the power of purchasing for the museum?—I do not exactly know. I imagine that at present it is only the Superintendent; at least he says that he has the power of purchasing, but that his general instructions are to purchase under the advice of the Keeper, but if he chooses he can purchase on his own responsibility.

10,243. Without consulting the Keeper?—I understand so. I think there is a little difficulty in that matter; but I have here a memorandum which I received from him just before I left Edinburgh, which will show the form in which it is done, and it is in these terms, "A skeleton and a stuffed specimen "Sieboldia Maxima are offered by Gerrard for 15*l.*; "do you advise their purchase?"

10,244. This is sent to you to inquire whether you think such a purchase desirable?—Yes.

10,245. On the other hand, supposing that you had seen something which you thought desirable, what would be your course?—I should have to recommend its purchase, I should think, to the Superintendent at present—I do not think that I could order its purchase as things stand now—the purchases must take place through the Superintendent, and very properly so, that is to say, the money is paid by him, and the transaction passes through him; but I do not know whether, at this moment, I am entitled to order the purchase or not.

10,246. Supposing you saw some very valuable and important specimens, your recommendation to purchase those specimens would not be sufficient authority for the Director to obtain them at once?—Certainly it would be a sufficient authority for him to do so.

10,247. I mean that he would not feel himself compelled to obtain them at once; he would feel that he had a concurrent judgment?—I should think certainly he would feel that he had a concurrent judgment. My recommendation he would consider as authorising, but not as obliging him to make a purchase.

10,248. That is rather a singular state of things for a scientific museum, is it not?—I think that the arrangement is very singular in all its aspects.

10,249. Supposing that in examining one part of the museum you saw that the arrangement of the specimens was entirely contrary to modern knowledge; supposing, for example, that you saw the Cirripedia placed amongst the Mollusks, would you have the power of altering that?—I have no machinery for altering it. I have no keys, and I have no assistants.

10,250. Do you mean to say that you have no direct access to the cases?—I have no key of my own whatever.

10,251. When you want a case opened, are you obliged to apply to the Director to have that case opened?—Certainly.

10,252. Supposing that you found some matter of arrangement which was entirely erroneous, you being held by the public responsible for that, can you, by writing to the Director, tell him that that is all wrong and he must alter it, or can you merely suggest that you think it ought to be altered, and he could do as he pleases?—Certainly the latter. He would probably tell me that I was mistaken, and that it was perfectly right; and I should, of course, decline to discuss the matter.

10,253. He, not knowing anything about the matter, might retain the erroneous arrangement, while you, as the specially responsible Keeper, might be entirely opposed to it?—He has over and over again in various forms reiterated his opinion that he is responsible for the arrangement.

10,254. I apprehend that that is quite contrary to the spirit of the Minute of the Lords of Committee of Council on Education, which was first read, defining the duties of the Keeper?—I think that the arrangement as it stands now is quite different from the one which was originally contemplated in all respects. Perhaps I may be allowed to read the present regulations under which the Keeper and the Director act, the regulations modified, at the time of my appointment: "My Lords, therefore, wish it to be understood that "they hold the Director of the museum wholly and "solely responsible for its administration, and look to "the Keeper for scientific advice in all that concerns "the Natural History collections. The Keeper will, as "heretofore, report annually to my Lords on the state "of the Natural History collections generally, transmitting his Report through the Director, and also "make special Reports at such other times as he may "find necessary. He should advise as to purchases "to be made, as to their arrangement, and as to that "of the museum generally. It is his special duty to "have a general scientific surveillance over the Natural History Museum, and to see that the different "departments are properly represented, and he should "bring to the notice of the Director objects which "may come into the market, and which it may be "important to add to the collections." Those are the duties assigned to me as Keeper.

10,255. Those do not seem practically to have been acted upon?—It is a sort of permissive state of things altogether; it really depends very much upon how the Director or Superintendent looks upon the thing. "The Director of the museum should, except in very "special cases, make all the purchases himself. He "is responsible for their arrangement and custody, "and for that of the specimens generally in the "museum, of which he has the entire control. But "he should be guided in the arrangement of the "Natural History Museum, and also in the purchase "of specimens, by the advice of the Keeper. As a "general rule, no specimens should be purchased for "the Natural History Museum without a recommendation to that effect having been first made by "the Keeper in writing. But if at any time the "Director should find it necessary to act without or "against the advice of the Keeper, who is his "scientific adviser, a special Report should in all "cases immediately be made to my Lords." I think that the intention was that the Director should be almost an honorary appointment, and that it it should be such an appointment as Sir Henry De la Beche held in London in Jermyn Street. It was intended that there should be a Director to have the general supervision; and I believe that the Keeper should have the actual *bonâ fide* keeping of the collection. At that time it was intended that there should be two Keepers, one of the industrial, and the other of the scientific division, the whole being under the general surveillance of a Director, who, in that case, would have been a scientific man of eminence, holding, to a certain extent, an honorary appointment; or either Keeper might have been also Director, as was contemplated in the cases of Professor Edward Forbes and Professor George Wilson.

10,256. (*Sir J. Lubbock.*) Will you inform the Commission what the tenure of the Superintendentship is; is it for life?—I cannot say. I should think it is understood to be a permanent appointment.

10,257. If I understand you rightly, your objection to the present system is, in the first place, that, practically, the University Professor has not got a convenient mode of securing specimens for his lectures; secondly, that the museum is under two heads, and, therefore, there is responsibility thrown upon you, whereas you have no power of carrying out your views with reference to the management of the museum?—In the first place, with regard to securing specimens for the illustration of lectures, I do not make any special complaint on that head, because I do not know whether it might not be made to work tolerably under the present system. There is no special difficulty about it. My great objection is that I have no power to have the museum arranged in a way suitable for the illustration of my lectures, and for what I consider the proper form of instruction in

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

Natural Science. I have no power to have a series completed and arranged for reference, or in fact to legislate or manage the museum as I consider right; I am held by the public responsible for the condition of the museum, and I am also held responsible by the University. Further, I have no other means of instruction. I have no other museum which I can put into a condition such as would be necessary for public and for University instruction in Scotland—it is the only museum at my diposal, and, from the position which I occupy, I am looked to for the efficient administration of the Natural History Department in this country.

10,258. I quite understand you to say that in your opinion, through the courtesy of Mr. Archer, there would probably be no difficulty in your obtaining any specimens which you might wish, but that is a very different thing from your having the power as Professor to demand the use of specimens as a right, and upon that point I understand you to say that although you consider that you have that right, it is, to a certain extent at any rate, disputed by Mr. Archer?—It is so. Mr. Archer considers that I am to receive specimens on application to him; for instance, if there were a specimen which he considered of too great value to be taken to the class, he would suppose that he had a right to refuse me the use of that specimen for purposes of instruction, and I do not think that that is a proper arrangement. Supposing a difficulty of the kind occurred frequently, I think that he should have the right to report, but I do not think that he should have the right to refuse the Keeper of the collection the use of any specimen that he chose; of course the Keeper ought to be extremely careful in using his discretion in the removing of specimens, but I think that the matter ought to be left to a Keeper who is in the position of a Professor in the University.

10,259, 10,260. I think that in his evidence before the Commission on the Science and Art Department in Ireland, Mr. Archer distinctly said, that while he considered that you had a claim to the use of the specimens, on the other hand he had a right to refuse any application if he thought that the specimens asked for could not be removed without injury to the public property?—Yes, he stated that. I put it on rather a different footing after I came to Edinburgh. He sent me at first a number of forms, of which this is one: "To the Director. Sir, I request that you will allow "the following specimens to be removed to my class "room for the purpose of lecture illustration, and I "hereby guarantee their safe return to the museum." That I thought was scarcely a suitable form with regard to a collection of which I am myself the Regius Keeper, so I changed the form of the application, and simply used this form: "Specimens required by the Professor "of Natural History from the Museum of Science "and Art." It is the same in sense, and an application on this form would be refused if Mr. Archer thought that it was not desirable to send the specimens; but I may mention that I have as yet never named a specimen. In order to prevent getting into difficulties, I have always asked that the assistant should select those specimens which could most conveniently be sent for the illustration of certain subjects. I have never mentioned a single specimen, because I have been extremely anxious, until the whole question was settled, to avoid any collision of any kind.

10,261, 10,262. (*Sir J. Lubbock.*) The question which I was asking you just now had reference to the constitution of the management of the museum; is it not necessary to keep in mind the broad distinction between the question of the constitution of the management and the judicious management of the museum?—Yes.

10,263. The two questions are perfectly independent; you might have a bad system of management under a very convenient constitution, or you might have a very bad constitution with a good system of management?—Certainly.

10,264. The most important part of your evidence, so far as the general principle is concerned, appears to me to be that the gentleman who occupies the nominal post of Keeper of the museum has really no practical power in the management of the museum?—Exactly so; but I think that the present system, if it were managed ever so well, would be most unsatisfactory.

10,265. You appear before the public as the nominal Keeper of the museum, and you have the responsibility of the management, and yet you have no practical power of management?—No, I have no practical power of management. The general Superintendent of the institution is not appointed as a scientific man, but he is appointed as an administrator merely, and then a great scientific collection is put into his irresponsible hands to do what he chooses with it, and that I think is a most unsatisfactory arrangement.

10,266. (*Dr. Sharpey.*) Are you aware that there is such an arrangement existing anywhere else?—Certainly no such arrangement exists anywhere else in the world.

10,267. (*Sir J. Lubbock.*) But the Superintendent of the museum at Edinburgh appears to be practically the Keeper of the museum?—He is practically the keeper of all its departments.

10,268. If, then, he were a person fully qualified for that post (and I am far from saying that he is not), as far as the museum is concerned there would be no reason why it should not be in most admirable order. The inconvenience would be with reference to the position of the Regius Professor in the University *vis-à-vis* the museum?—I think that it is quite impossible that any man could satisfactorily manage the whole of such a museum as the one in Edinburgh. It represents for Scotland, South Kensington, and the British Museum, and involves every department; it is a complete industrial museum in one of its divisions, including engineering and mechanics, food, raiment, chemistry applied to arts and manufactures, *Materia Medica*, sculpture, painting, and ornament of all kinds, ancient and modern, ceramic art, besides, in the other division, geology, scientific zoology, and mineralogy; all the various departments which are represented in all other museums are represented there more or less fully; and I do not think it is possible that one person could be able to manage the whole. I believe it is quite possible that he may manage the whole of the industrial division well enough if he be a person accustomed to that sort of thing; but I think in that case he would not be a man of the class who would be capable of managing, at the same time, the scientific department of the museum. I do not think it possible that one man could manage the whole of such a museum in all its departments, that is to say, I think he might quite well superintend the whole, but that he could not actually interfere with his own hands with safety with all the departments. If he did so, there would be errors and losses certainly in many of them, and those errors would probably be in the scientific division, where the errors are most important, and the losses possibly irretrievable.

10,269. In the case of any museum, of course there must be some one head, either an individual or a body of individuals, and you must trust to their discretion to avail themselves of the best advice which is open to them with reference to those departments in which they are not in a position to judge for themselves; that would apply to any museum, would it not?—Yes, certainly; but in the case of the Edinburgh Museum, that body appears to be the Science and Art Department, the body who have the actual control, the body of reference who meet and who appoint the different officers for different purposes.

10,270. Then you would suggest that in the Edinburgh Museum there should be heads of departments who should communicate directly with the Science and Art Department at Kensington?—I think in the Science and Art Museum in Edinburgh the first arrangement which was made would work tolerably well, that Mr. Archer, for instance, should occupy the position of Superintendent; it is a convenient term, and it is the most intelligible. I do not know that there is any reason why he should not be called

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

Director, if there is any object in calling him so, but he should practically be the Superintendent of the whole museum, and with special reference, as stated in the minute, to the collections of products, and in fact to the popular or show part of the museum; and that the Natural History Museum, which was actually handed over to the Department by the University, should be under the keeping of its own Keeper, reporting directly to the Science and Art Department, but the Keeper being understood to make his arrangements in the Natural History Museum suit the general administration of the building by the Superintendent.

10,271. Then what would be the relative position of the Superintendent of the museum and the Keeper of the Natural History collections?—I think that they should have as little to do with one another as possible.

10,272. Then you would propose to take the Natural History part of the museum entirely away from the Superintendent, and treat them as two different collections, although they might be in one building?—As for instance the Botanical Department and the Zoological Department are treated in the British Museum. You have each of the Keepers in the British Museum responsible for his own Department, and each Keeper gives security for the safety of the objects in his Department, and yet the whole is nominally under the general direction of the Principal Librarian; but the Principal Librarian has no power to interfere with the classification of Dr. Gray's animals, and he has no keys of Dr. Gray's cases.

10,273. But he is nominally the head over the whole?—Yes; he is the nominal administrative head of the whole establishment.

10,274. And you would propose that in the same way the Superintendent of the Edinburgh Museum should be the nominal administrative head over the whole, but not interfering with the management of the Natural History Department?—Certainly; that, it seems to me, is the only way in which it could be satisfactorily arranged.

10,275. Do you consider that the Regius Professor of Natural History should be *ex officio* Manager of the Natural History Department?—I think that in every way it would be more convenient that it should be so. The whole of that collection, and a very splendid collection it was at first, and it produced nearly about 800*l*. a year from admissions only, was actually made by Professor Jameson. The Professor of Natural History in the College has very great advantages in procuring specimens. Since I came there I have been offered and have got thousands of specimens, which I have been unable, however, to put into the museum, because there is no one there who can arrange them and mount them. I think, therefore, it is a very great advantage to the museum that the Professor in the University should have a special interest in it, which, indeed, he must have, for he is the recognized official representative of Natural History in Edinburgh, and it is the only collection through which he can carry on public and professional instruction in his department.

10,276–7. Would not the practical effect of that be, that the Government would hand back the Natural History Museum to the University, subject only to the right of admission on the part of the public on certain days?—He has the charge of the museum, I imagine, as an Officer of the Department, and not as Professor. It is merely a convenient arrangement that the Professor should retain what he has always had, and that it should go along with the Professorship. The Department could in no other way have the services of an Officer of such acknowledged fitness, on such low terms.

10,278. Then the Professor would not be *ex officio* Manager of the Natural History Museum, but you would consider it would be convenient that the Science and Art Department should appoint whoever might be the Natural History Professor for the time being as the Manager of that part of the Collection?—I should mention that the Professor of Natural History in the University holds a distinct appointment from the Crown, from the Home Office, as Regius Keeper, but subject to the arrangements of the Science and Art Department.

10,279. But the Regius Keepership appears to be a nominal office?—It has been reduced to that.

10,280. The Regius Professorship is an appointment for life, is it not?—Yes. I understand that the Regius Professor holds his post under the University, and the Regius Keeper under the Science and Art Department, although they are both appointed by the Crown.

10,281. You would not recommend that *ex officio* the Regius Professor should be the Manager of the Natural History Museum, although, as a matter of practice, you probably would think it convenient that the two offices should be combined in one individual?—I think it would be convenient, and probably perfectly safe, that they should go together. I think that the University has a great claim upon the Museum, having handed over the whole of the very valuable Collection to the Science and Art Department, and having handed over to the Department all the means which it has of instruction; and I think that in such an University as that of Edinburgh, the Professor might, as a rule, be trusted to have the general Superintendence of the Natural History Collection; I think it would be very advisable that the Natural History Museum should be infused with the spirit of the teaching in the University, as the centre as it were in Scotland of Natural History Teaching.

10,282. I do not doubt that it would be, as a rule, extremely convenient that the Regius Professor should be the Manager of the Natural History Collection; but what I wish distinctly to know is, whether, in your opinion, it would be desirable that he should be so, *ex officio*, or not?—That depends upon the exact sense in which the term is used. I should not like to express an opinion upon that subject without considering it more fully, for I do not quite see what the bearing of it might be.

10,283. I take the bearings to be these, that, in the one case, if he is *ex-officio* Manager of the Natural History Museum, there is no possibility of making any change if it should be found that his management of the collection is not satisfactory or judicious; whereas, if the appointment is made by the South Kensington Authorities, they would have the power of cancelling his appointment if they should find it desirable to do so?—I think it would be most undesirable that the South Kensington Authorities should have the power to cancel any such appointment, unless some change were made in their central organization, so that such cancelling should be done under the advice of a responsible Scientific Board. I think it would be extremely awkward if the Home Secretary were to appoint a Regius Professor and a Regius Keeper, and if for some reason, which might be good or bad, the South Kensington Authorities had the power of cancelling the appointment of Regius Keeper, that is to say, cancelling part of the appointment made by the Home Secretary, and I think that it would not be satisfactory that the appointment of the Regius Keeper should be in the hands of the South Kensington Authorities, unless there were a Scientific Board such as I have suggested. I will simply say what would be the result in the present case. There is not the smallest doubt that the management of the Natural History Collection would be removed from my hands. It might probably be a more satisfactory arrangement from the point of view of the South Kensington Authorities that I should be put out of the way altogether; at least, taking their view of these things, I should certainly act in that way, and so get rid of the scientific difficulty entirely.

10,284. Surely it is the most inconvenient system of all, that a gentleman should be nominally Keeper of the Museum, responsible in the eye of the public, and yet without any power to carry out his own views?—I think it is a bad arrangement; and one way of getting out of it, of course, would be to remove him.

10,285. One great part of the inconvenience arising from the fact that the appointment to the Regius Pro-

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

fessorship is in the hands of the Home Secretary, and that of the Superintendent of the Museum is in the hands of the South Kensington Authorities?—I do not see any inconvenience arising from that circumstance. The reasonable object of the Department is not to grasp the collection, but to have it properly administered, and it seems to me that being in a position to secure the assistance of the Professor gives them special facilities in doing so.

10,286. The Keepership appears practically to be a nominal office?—It has become very nearly so.

10,287. (*Chairman.*) The two appointments of Professor and Keeper are united, but one of them is practically reduced to a nullity?—Yes, that is about the state of things at present.

10,288. (*Sir J. Lubbock.*) I presume that if the Regius Professor is Manager of the Natural History Collection, it would be necessary for him to have a very competent assistant?—Certainly. I may mention with regard to that, that I think he ought to be so competent as to be able to take the practical charge of the Natural History Collections, and merely to get general instructions from the Professor. The Professor cannot devote a great amount of time to the Museum. He is not remunerated for doing so, and it is not expected of him. I think he should merely give general instructions, which should be carried out by a thoroughly competent assistant.

10,289. (*Sir J. P. Kay-Shuttleworth.*) He being responsible for the acts of his assistants?—Yes, being responsible for the acts of his assistants. I see no objection to his providing security, if that were considered necessary, for the collection. I think, in fact, that in some way the Keeper should be made distinctly responsible for the collection.

10,290. (*Chairman.*) Do you know whether the Natural History Collections are much visited by the public at present?—A good deal, for they form part of the general collection, and the visitors to the different parts of the Museum generally pass through the Natural History Galleries, which I believe are considered very attractive. During the day there are few visitors, but at night, particularly in the winter, the building is brightly lighted and warmed, and is extremely comfortable, and large numbers of people go to the Museum. I do not think that the Natural History Museum is much visited for the purposes of instruction, but for the purposes of amusement simply, in 99 cases out of 100.

10,291. Are any popular lectures delivered in the Museum?—Lectures are delivered to the working classes by the Professors and others. I delivered a course of six lectures myself this winter.

10,292. (*Sir J. P. Kay-Shuttleworth.*) Is there a lecture theatre for that purpose?—Yes.

10,293. Does anything occur like a Professor or an Assistant Professor and Demonstrator going through the collections at certain periods of the day, and explaining the collections to such a concourse of people as may happen to be there during the evening?—It has never been done as yet, and I do not think that it could be very conveniently done at present. I think that the collection would require to be considerably remodelled before anything of that kind could be done in a satisfactory way. In fact, the collection requires remodelling, thoroughly, to make it suitable for the purposes of instruction.

10,294. (*Chairman.*) If it were remodelled in the way that you would think desirable for the purposes of instruction, do you think it would become less attractive to the public generally?—I am perfectly convinced that it would become much more so.

10,295. More so to the class of persons who visit it now?—I think so. It is the general lighting and effect of a museum which is the great attraction to the classes who go now. I know that our own servants go, for instance; and I hear the general opinion of the Museum, and I know that it is thoroughly respectable, and an exceedingly suitable place for people to go to in the evening, being warm and pleasantly lighted; but they certainly do not go for the purpose of instruction in Natural History. The Free Museum in Liverpool is exceedingly popular; large numbers of people go, and that Museum is extremely well arranged.

10,296. (*Dr. Sharpey.*) Do you know under what government that Museum is?—Under a Committee.

10,297. It is not maintained at all by public money, is it?—The Free Museum was the gift of Sir William Brown; it is maintained now by a rate.

10,298. (*Chairman.*) Then you have no fear that by arranging the Edinburgh Museum as you would wish to see it arranged for scientific purposes, it would become less useful or less attractive to the public generally?—Certainly not.

10,299. Is that the view of the Science and Art Department? do you think, in their present system, that they look not so much to the scientific teaching at the University, but to make the collection attractive to the public?—I think that that is entirely their view, but I think that they are completely mistaken in that view. Besides, I do not think that they attach sufficient value to the scientific uses of a museum of that kind. Probably it is from want of thoroughly understanding the subject. I feel perfectly sure that if there were a Scientific Council connected with the Science and Art Department, they would at once see the desirability of what I recommend. I do not think there can possibly be any collision between the University and the Museum.

10,300. (*Sir J. P. Kay-Shuttleworth.*) The popular use of museums at present is amusement as compared with instruction?—Certainly so.

10,301. But you conceive that the popular use of museums might be extended to instruction by various expedients?—Yes, I think so certainly. I think that a museum ought in the first place to contain as attractive a general collection as possible, and then, I think, probably separated from that collection, or combined with it in some way, but I think most probably separated from it entirely, there should be a museum which would be a type and model for imitation in local collections; a type museum on a very full scale, so that teachers, for instance, could come there and find all that was necessary for their study.

10,302. (*Dr. Sharpey.*) You would intend those local collections not merely to be places of recreation but of instruction?—Of instruction certainly, to be used by Teachers in Science; and I should wish that the one in Edinburgh should be specially suited to the use of all classes of teachers, up to the University, which gives the highest teaching.

10,303. Have you considered at all the means of establishing and maintaining local collections?—That matter has been, of course, very frequently discussed, from time to time, and I think that a central institution, such as the Museum in Edinburgh, would be probably extremely useful in preparing small collections, and providing *nuclei*, as it were, for local collections; and that probably an assistant in the Museum should be prepared to go anywhere, from time to time, and give instruction, and point out what is the best way of starting a local collection, so as to make the local collection actually useful for the purposes of instruction, and should inspect it from time to time.

10,304. At whose expense do you suppose those local collections to be got up?—I am not prepared to say at present from the present position of the education question in Scotland. In fact, that is a subject which I could not go into just now, for I am not sure how it would work. I think that there should be a small local collection connected with every superior school, as we find in Northern Germany, and in Denmark and Sweden, and I think that an assistant in a central establishment, such as the Museum in Edinburgh, ought to be able to give instruction to schoolmasters as to how to select such a collection, and should, if necessary, be able to supply a small model collection, giving the most important forms for illustration of both zoology and geology.

10,305. Would you contemplate that such a collection should belong exclusively to a school, or might it not be a collection in a town for public recreation as

C. W. Thomson, Esq., LL.D., F.R.S.

17 April 1872.

well?—I think, wherever it is possible, such a collection ought to be managed by a local society. I think that that would be found very frequently possible.

10,306. It might be available for two or three schools?—Yes, it might be available then for two or three schools. I think it always ought to be so in anything like a large town. I think a collection of that kind should be available for general instruction, and that the specimens should be freely sent under certain regulations, and should be used for educational purposes as much as possible. I have had some experience of that in Belfast. Within the last few years a local society there has taken up the natural history of the locality, and they have really made an extremely useful Museum which is perfectly available for all purposes of instruction in Natural History there. Of course, there is just wanting what we could supply them with, and that is the assistance of some one who thoroughly understands the subject in providing, or in teaching them how to provide, preparations illustrating structure; that is generally what they want.

10,307. The pupils could be taken to such a collection, or the specimens might be lent for use in the schools?—That might be so, certainly.

10,308. How is the Belfast one supported?—By the contributions of the members. It has no public assistance from the rates.

10,309. Is there a distinct Museum for the Queen's College at Belfast?—Yes, a very nice collection, independently of that of which I am now speaking, and the College Museum is always open to the public. When I was there the specimens, so far as we could go, and the diagrams, were freely used by anyone who wished for them for the purposes of instruction, and given perfectly freely from the College collection. In Edinburgh, everything has been removed from the University, so that there is not one single specimen left. I have a very considerable collection of Invertebrata which I use myself, as invertebrata are almost wanting in the general collection; but every specimen which belonged to the University has been removed, even all the diagrams belonging to the class, which is really a very serious inconvenience. I think that the Keeper ought to have it in his power, within ordinary reason, to put things of that kind where they will be convenient for the purposes of instruction. I think it is a mistake that the whole of the diagrams, for instance, should be removed from the private room of the Professor, which adjoins the Museum, and put into a cellar under the Museum. As a matter of simple common sense, I think it is a stupid thing, because the students are constantly coming for information, and wishing to see illustrations of one thing and another, and it is quite impossible that they can see them, just simply from a perfectly unnecessary obstruction.

10,310. (*Chairman.*) Is there anything further which you would wish to state to the Commission?—I am not aware of anything.

The witness withdrew.

Adjourned to Wednesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 24th April 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

Lieutenant-Colonel ALEXANDER STRANGE, F.R.S., examined.

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

10,311. (*Chairman.*) I believe you are Inspector of Scientific Instruments in the India Department?—Yes.

10312. And were formerly engaged in the Trigonometrical Survey of India?—Yes.

10,313. You have paid much attention, have you not, to the question of the importance of the cultivation of science in a national point of view?—Yes, for the last ten years I have paid great attention to the subject.

10,314. Will you be so good as to explain to the Commission the views that you entertain upon the subject generally, as to the importance of the cultivation of science?—I can hardly do that better in a few words than by stating the four postulates on which I base all my recommendations; and I merely wish to add that it seems to me indispensable that I should state the basis upon which I am about to speak. Those postulates are as follow:—(1.) That science is essential to the advancement of civilization, the development of national wealth, and the maintenance of national power. (2.) That all science should be cultivated, even branches of science which do not appear to promise immediate direct advantage. (3.) That the State or Government, acting as trustees of the people, should provide for the cultivation of those departments of science which, by reason of costliness, either in time or money, or of remoteness of probable porfit, are beyond the reach of private individuals; in order that the community may not suffer from the effect of insufficiency of isolated effort. (4.) That to whatever extent science may be advanced by State agency, that agency should be systematically constituted and directed.

10,315. Will you be so good as to enumerate the machinery that at present exists for securing the objects to which you have referred?—The principal existing State scientific institutions are,—1. The Royal Observatory, Greenwich, under the Admiralty; 2. The Royal Observatory, Edinburgh, under the Office of Works; 3. The Royal Observatory, Cape of Good Hope, under the Admiralty; 4. The Observatory at Madras; 5. The Observatory at Calcutta; 6. The Observatory at Bombay; those three being under the India Office; 7. The Ordnance Survey of Great Britain under the Office of Works; 8. The Great Trigonometrical Survey of India under the India Office; 9. Exchequer Standards Office, under the Board of Trade; 10. The Royal School of Mines and Royal School of Chemistry, under the Privy Council; 11. The British Museum, governed by Trustees; 12. The Meteorological Office, governed by an unpaid committee of the Royal Society under the Board of Trade; 13. The Royal Botanic Gardens, Kew, and those of Edinburgh and Dublin, under the Board of Works; and 14. The Geological Survey, under the Privy Council. I wish at this point to draw particular attention to the number of departments concerned in science. According to my list, which probably is not quite complete, there are six departments, all of which have many other matters to attend to besides science. I would now proceed to divide my remarks on those institutions into two heads, their insufficiency and their want of system.

10,316. Will you be so good as to explain to the Commission your views as to the sufficiency or insufficiency of those arrangements?—I will take them seriatim. I would take astronomy first, and I would say regarding that, that our present astronomical arrangements were made many years ago, and chiefly, if not

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

entirely, for the avowed purpose of assisting navigation. The chief Astronomical Institution under the State is the Royal Observatory at Greenwich, and that amply fulfils, I think, the purposes for which it was instituted, and, indeed, it more than fulfils them, because I consider that the extent and the refinement of the observations taken there are not absolutely needed for the purpose of navigation. For instance, there is a great telescope there, and I think very rightly there; not a single observation taken by which, so far as I know, is of any direct use to navigation. The next great instrument there is the transit circle, which also produces results in the shape of very extensive catalogues of the smaller stars which are not indispensable to navigation, and a third large instrument there is the altazimuth, which was erected by the Astronomer Royal for the express purpose of accumulating data on which to perfect the lunar theory, with a view to the application of that theory to the determination of longitude at sea. With respect to that instrument, unless I am misinformed, at present lunar distances are very little employed at sea,—in the royal navy very little, and, according to my own experience, in the Peninsular and Oriental Company's steamers not much. On board the vessel in which I came from India there were no lunar distances taken during the whole voyage. In the West India Mail Steamer Line, by which I have also sailed, no lunar distances were taken, the dependence now being chiefly on chronometers. I mention this point, not by any means to depreciate Greenwich, but exactly the reverse, in order to fortify the opinion I have given that Greenwich even exceeds the purposes for which it was instituted. But since Greenwich was instituted, and even in very recent times, a totally new astronomy has grown up, a branch of science which deals, not with the movements of the heavenly bodies, not with the great theory of gravitation, but with the physical constitution of those bodies. And now the importance of investigation into those subjects is on all sides, in all civilized countries, by all men of science, whether astronomers or not, admitted to be of enormous value both to philosophy and to practical utility. The knowledge of the sun, as it appears to me, and to most physicists of the present day, has a direct bearing, for instance, on what we call, but what does not deserve to be called, the science of meteorology. And, therefore, it seems to me that looking at these matters first, as we ought to do, I think, from the utilitarian point of view, the study of the sun, as one of the principal objects of physical investigations in astronomy, should be most systematically and pertinaciously entered into; and this can only be done, in my opinion, by such institutions as the State can maintain in continuity and efficiency.

10,317. In your opinion would it be impossible for the Observatory at Greenwich to undertake such observations?—In my opinion it would not be impossible, but it would be undesirable, for these reasons, that in the first place Greenwich cannot be moved, and the area upon which the Observatory is built is very limited in extent, and at present, even already, the instruments are unduly crowded. I may mention, as one illustration, that the recently erected collimators of the great transit circle, which you may say constitute the principal meridian of the civilized globe, protrude through the walls of the Observatory. There is not room for them; therefore, as a mere question of area, I do not think there would be room for the very extensive Observatory which would be required for physical research. That is one reason. Another reason is, that I think the order of mind which is best suited to what I would call mathematical astronomy, is not the best order of mind to employ upon the physics of astronomy. I do not say this with regard to the present Astronomer Royal, because, if there is a man living who would combine those two qualifications I think it is Mr. Airy, but still I state my opinion that on the principle of the sub-division of intellectual labour, it would be better that the branch of astronomy of which I am now speaking, which I look upon as one of the most important subjects that can be discussed at the present day in science, should be under a different administration altogether from the present. Those are my two reasons for thinking that it would be better not to add this class of observations to those taken now at Greenwich. [*See* APPENDIX VII.]

10,318. Could you state to what extent such observations as you have now referred to are conducted by means of private observatories, or the observatories of the universities, and other public bodies?—It is rather difficult to get from private individuals exact information upon this point, but, so far as I know, those studies are not systematically conducted, and not fully conducted by any university, or by any private individual. One section of such observations was conducted some time ago at the Kew Observatory, that is to say, the photographic delineation of the sun's face was conducted in an irregular, confused sort of manner, as most things connected with science are conducted in England, partly by means of grants from the Government, partly, I think, by means of grants from the British Association, and partly by means of private liberality. But that series of researches has come to an end. It has been officially announced by the principal promoter of them, Mr. Warren De La Rue, that they have ceased. Therefore, at present, that particular method of studying the sun is not now pursued, I believe, by any institution or any individual systematically in the British dominions. Then, with respect to the second mode of studying the sun by the use of the spectroscope, there are several private individuals who are pursuing that, and one by the aid of the Royal Society, Dr. Huggins, that is to say, the telescope is suitable for the spectroscopic examination of the sun, but I understand that Dr. Huggins employs it not so much for that purpose as for researches on stellar, nebular, and cometic spectra. The Royal Society some three or four years ago, when I was myself on the council, voted a sum of money for the construction of a large telescope to be placed in the hands of Dr. Huggins, who undertook on his part to erect an observatory for its shelter, and to apply himself sedulously to using it. I think it is as well that I should mention here that though I voted with the rest of the council for this grant of money, being anxious that every aid that was possible should be given to science, still, I objected then, as I object now, to an arrangement which I did not think a satisfactory one. It did not promise such continuity, nor was there present that element of responsibility which I think is essential in such matters. It is possible, on Dr. Huggins's death, for instance, that there might be some difficulty with his executors regarding this double arrangement; and, moreover, I did not think that a great undertaking like that should devolve upon a private individual; I thought it a matter great enough for the nation to take up, and I still hold those views. I may add that the telescope which I spoke of was lent to Dr. Huggins, and it is the property of the Royal Society still.

10,319. (*Professor Stokes.*) Are you aware that a deed was executed between the Royal Society and Dr. Huggins relating to the possession of it?—I am aware of it.

10,320. Would not that obviate any difficulty on that score?—I am also aware that deeds are not always devoid of legal difficulties. I know that from fatal experience, but my chief objection is that researches cannot be carried on with the same fulness and power by a private individual as they can by the State, nor do I think that the State should look to agency of that sort for doing what is national work.

10,321. (*Chairman.*) Are you of opinion that work of this kind will not be satisfactorily executed by private effort, or by the exertions of public bodies, such as universities?—I think not, the element of continuity of all things being wanting in the case of private effort. If I might make the remark, on that point of continuity, I would say there have been recently some very remarkable papers read before

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

the Royal Society, as the Commission are well aware, by Mr. De La Rue, Mr. Balfour Stewart and Mr. Loewy, with regard to the Kew series of photographic observations that I have alluded to. Quoting from memory, in one of those recent papers it is stated that about one day in two affords a photographic record of the sun, that about one half of those records have to be rejected, because it is not possible to trace out the continuity. It is found of great importance, for instance, that a particular spot on the sun's face should be followed up throughout its course of existence, and about one half of those observations, thus reducing the whole number to a quarter of the year, must be put aside as not capable of being used for that purpose, and that even those that are used are more or less subject to the doubt arising from the broken character of the series. Therefore, it seems evident to me that in a climate like that of England it is hopeless to expect the continuity that is needed, and that whilst I advocate strongly the establishment of an observatory in England for this purpose, I am quite satisfied that that observatory alone will not suffice, and that we must have recourse to our extensive possessions in all parts of the world, upon which it is said the sun always shines, to obtain continuity of results, because I may here state that it is perfectly possible to combine pictures of the sun taken at two opposite sides of the globe. The difference of local position will not militate against their being used, and, therefore, as part of my recommendation, I should say that observatories for this purpose require to be established elsewhere, and I am now myself making that recommendation to the Indian Government, justifying it on the ground of the application of such observations to what are called meteorological purposes.

10,322. Where space admits, should you prefer those observatories that you recommend being attached to existing observatories?—I rather think not. I would rather have them there than not have them at all, but I think that they should be distinct, for the intellectual reasons that I have given.

10,323. You have spoken of the observatory at Kew. If it were thought proper would that building be adapted for the purposes of which you have now been speaking?—I think it would, with, of course, the necessary additions, but it is well placed for such a purpose, being quiet and accessible from London, and I think it is a great object that such an observatory should be near London, the centre of all intellectual activity, and that Kew would be a very fitting place indeed for it.

10,324. What is the present position of the Kew Observatory?—It used to be maintained principally, as the Commission knows, by the British Association, but it having been represented, with, I think, great justice, that too large a proportion of the funds of the Association were applied to that class of observations, the British Association recently ceased to maintain Kew, and then, as is well known, Mr. Gassiot came forward, and by means of a large sum of money, which he placed absolutely at the disposal of the Royal Society, created a fund for the maintenance of Kew for particular purposes, but amongst those purposes, so far as I know, the study of the sun was not mentioned. It has been constituted also one of the stations of the Meteorological Office, but that connection does not contribute at all, I think, to the objects aimed at by Mr. Gassiot, and, in fact, now it is a sort of mixed institution, partly official and partly not official. I fancy that the two branches are kept tolerably distinct, but so far as the building is concerned it appertains to the two bodies.

10,325. Are physical observatories for the physics of astronomy, such as you have recommended, buildings, the establishment of which would involve any very considerable outlay?—I should say not, compared with the objects in view, because, of course, that is the only way in which such a question could be viewed. The first outlay on instruments would have to be large, but it would be once for all.

10,326. (*Professor Smith.*) As compared with an observatory for meridional observations, would it be expensive?—I should think it would not be so costly either in erection or in administering. I think the staff would hardly require to be so great. Certainly the reductions would not be so costly.

10,327. (*Chairman.*) Are there any other matters connected with astronomy upon which you would like to make any observation before we go to meteorology?—I beg to allude to a matter to which I feel rather obliged to allude, as it came to me officially, a matter brought to the notice of a committee of which I was chairman, by Mr. G. F. Chambers. The question was raised by him as to whether the printing of the observations of the Royal Observatory is not carried into too great detail. I only feel it right to say that that was one of the specific points brought to our notice, and I may here add that very few specific points were brought to our notice, and I therefore feel bound to allude to it; but without accepting Mr. Chambers' views or endorsing them. It is a point which it might be as well to inquire into, although I do not think it is a point of any great importance.

10,328. You do not wish to express any opinion yourself upon that point?—No. I should myself adopt the opinion of Mr. Airy, whatever it might be. I think he is the most competent person to decide a question of that sort. But I wish to say this, that it seems highly desirable that original records of observatories, and of all scientific institutions of whatever kind—such original records as it may not be considered expedient to print—should be accessible, under proper regulation, to men of science. That is a question which a committee of the British Association is now considering. I am a member of the committee, and I have recently approved the draft of a circular that is being addressed to all existing observatories, asking them how far they are prepared to facilitate that object? I consider it is a very important one indeed. As a matter of right, men of science, under proper guarantees of course, should have access to the original records—by "original records" I mean records existing only in manuscript, or in the case of photography in the shape of negative photographs—and so on: that is all that occurs to me at present on the subject of astronomy.

10,329. We will now go to the next subject—that of meteorology; there is at present a Meteorological Office, can you state to the Commission the constitution of that office?—The constitution of that office is, that on Admiral FitzRoy's death, the Royal Society, being consulted, advised that an annual sum of 10,000*l*. should be spent on meteorological observations, and that the application of this money should devolve upon a volunteer unpaid committee of the Royal Society; that is the present existing state of things.

10,330. How is the present system working?—In my opinion it is doing very well what it professed to do, but it is very far from fulfilling what is required. I have with me, sent to me in my official capacity, the Quarterly Weather Report of the office from July to the end of September 1870. It is admirably arranged; it contains curves for every month, and for all the seven stations amongst which its work is distributed. It gives curves for every month of the wind, direction and pressure, vapour tension, barometer, and thermometer, and rainfall. The way in which that is done is exceedingly ingenious and good, but I don't see in this report, or any that have come under my notice, the smallest allusion to what I conceive to be the most important of all meteorological phenomena. I do not see the smallest allusion to the sun in any shape or way. I do not see that even the solar radiation by means of thermometers is measured, and that is the very lowest class of investigation that can be applied to the same. I do not see that atmospheric electricity is mentioned, and though the rainfall is given for those seven stations, I look upon it as absolutely insufficient. For instance, for agricultural purposes, one of the chief objects of meteorology, it is absolutely insufficient. It is not that we

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

want merely the rainfall at seven points in Great Britain, but we want the rainfall all over Great Britain, and that, if I may judge by this report, the Meteorological Office does not attempt to do. It is done, as is well known to everybody, by Mr. Symons, a private individual, who is doing it, chiefly because he is interested in the matter himself, and aided by the funds of the British Association. I think that is a national object which comes distinctly within the duties of any organization assuming to be a State Meteorological Department. I see, also, by this report, a great deal of matter which I myself do not think of much value. What we want in meteorology is what we possess in astronomy, namely, the power of prediction. I do not say that we shall some day have a meteorological almanac, in which the temperature, and the pressure, and the rainfall of every day in the year will be tabulated four years in advance. I do not say that, but I do say, that unless we hope to be able to predict in a large way the probable courses and vicissitudes of the seasons I do not know what we are labouring for. Prediction I conceive to be the great object of meteorology, and that is not attempted by the Meteorological Office. I do not think that their observations will ever assist alone in enabling us to predict the weather. In conjunction with the observatories that I have been alluding to, which are of that mixed kind, and which belong partly to astronomy and partly to meteorology, there is no saying what we may not do; but, looking at this as an ostensible arrangement for dealing with meteorology, it is quite insufficient to obtain what meteorology is cultivated for; that is to say, for prediction. Then this report deals a great deal with what possibly may be interesting to the general reader, but I think it is valueless to science, or nearly so, that is to say, there are such remarks as these on every month: "The atmospheric pressure "was above the average at all observatories, the "difference being greater in the north." I cannot see that that is of the smallest scientific value. I see in the month of June, on page 54, "The weather was "warm everywhere during the month, especially in "England." That is not science, and, therefore, I do not consider that the Meteorological Office comes up to the wants of meteorology. Perhaps, whilst on the subject of that office, I may say, if I may give my own personal impressions, that I myself, personally, do not think that an unpaid body is the proper sort of body to govern an institution maintained by State funds. I think that the element of responsibility, except what some people call moral responsibility, which I think a very indefinite term, is totally wanting. I think, moreover, that the effect of placing over a man of science, director of any institution, a body of that kind is calculated to dwarf him and cripple him, and thereby produce unsatisfactory results. And more than that, I do not think that it is the best way to get the best man for such posts. I do not think that men of the highest acquirements and the highest distinction in science, who are the men that the State should employ in such positions, would accept such a post, or that they would subject themselves to the interference, for that is the right word to use, of a voluntary body like that. With respect to this, my remarks, I would wish to say, are not in the least personal. With respect to the present committee, it is composed of men of very great eminence and high fitness for the purpose; albeit I do not quite approve of their system. And, moreover, I believe that they are assiduous in the performance of the duty that they have undertaken, but it must not be forgotten that this office is a child of their own creation, and that the parental affection which they would naturally feel for their own offspring would possibly be wanting in their successors. I do not, therefore, think that it is good as a permanent arrangement; it is not of the right kind for the purpose. I do not think it is one that would work hereafter, however it may work now.

10,331. By whom is the report of which you have been speaking drawn up?—By the Meteorological Office; it is an official report.

10,332. Who appears to be responsible for the contents?—It is signed by the director, Mr. Scott.

10,333. Is the head of the office a scientific person?—Mr. Scott is the head of the office, and he is a person who has been engaged in science for some years. I should be glad if the Commission would allow me in connexion with the remarks that I have made upon that report, to say that I have here two other reports, a Stonyhurst College report, Stonyhurst being one of the seven stations under the Meteorological Office; and the Report on Meteorology by the Royal Cornwall Polytechnic Society, which latter is more of a private character, and I bring them forward because, although the State is in no way responsible for them, still they indicate the state of science in that matter. I merely say that they are as insufficient in my opinion as that one of which I have made particular remark, the sun being totally ignored, and atmospheric electricity being ignored also, and the remarks being of the most general and, sometimes, I think, in a scientific sense, useless character. I look upon meteorology as the most backward of the physical sciences, so backward do I think it in England that I deny its right to be called a science, because in my opinion it has no scientific basis whatever.

10,334. (*Professor Smith.*) Are you acquainted with the meteorological observations of the Radcliffe Observatory at Oxford?—I am not. I have not received their reports, and I do not know what they may be.

10,335. Does the committee of the Royal Society give more than a very general supervision to the work of the Meteorological Office?—I am unable to say that of my own knowledge, but they are the governing body of the institution, and I have been given to understand that they meet very frequently.

10,336. But you are not aware of any undue interference on their part?—Certainly not. I should not wish to impute that, but at the same time I think that as they have undertaken that duty, it is their business to interfere, and it is that that I object to.

10,337. (*Chairman.*) You stated that there are seven meteorological stations. Are the buildings in each of these provided by the Government?—I think not. I think they avail themselves of existing buildings to a great extent, of which Kew is an example. The stations are Valentia and Armagh in Ireland, Glasgow, Aberdeen, Falmouth, Stonyhurst, and Kew. I may add, as I have mentioned seven of these stations, that the observations are mainly taken by self-recording apparatus, of a very elaborate and perfect character, provided by the Government. It is right that I should add that marine meteorology receives some attention under the able superintendence of Captain Toynbee, who formerly commanded one of Messrs. Green's ships, and that captains of vessels receive assistance in instruments and instructions; but I do not value very highly work performed in this voluntary manner.

10,338. What would you recommend should be done by the Government on this subject?—It is one of the widest subjects I think that has to be considered in dealing with science. I have already said that I think it requires to be spread over the British dominions, and in saying that I alluded at the time particularly to observatories for astronomical physics, which is connected with meteorology, but meteorology is of no use whatever unless it is studied all over the surface of the globe. I look upon local meteorology as useless for the extraction of great laws. It may be of great service to the inhabitants of the particular spot—that is a very narrow object indeed; but for the high purpose of prediction, founded on generalization and knowledge of laws for high objects, meteorology must be spread over the globe: therefore it must be more than national; it must be international. Hence, I conceive that any action taken by the British Government in this matter should be taken in concert not only with foreign nations, but with the Colonial Office and the Government of India. I think it will never be effectual unless that is done. And then the system should be the same throughout as nearly as it can be made so, that is to say, the same instruments, the

Lieut.-Col. A. Strange, F.R.S.

24 April 1872

same units, the same scales, and tables, and constants, and methods of observation and reduction, should be observed throughout the civilized globe. That, I think, is the only way in which meteorology can be effectually advanced, and I consider that the British Government should take its part in that great system. With regard to the number of observatories and the course of observation, and all these matters, I apprehend that the Commission would hardly wish me to enter into details of that kind, for an infinite number of details would have to be considered, all requiring great attention, but sketching it in a broad way I think it is essential that it should be an international administration. I think also that certain vessels of the Royal Navy should be sent to unfrequented parts of the ocean to make meteorological observations. The same ships might be employed for other scientific purposes to be presently referred to.

10,339. Assuming that the British Government were to adopt your views, are you prepared at all to say how far other nations would be inclined to cooperate? have they shown a greater disposition to encourage the study of meteorology than the British Government?—In Germany the subject has received very great attention, and in Russia, France, and Italy also. All those nations have paid very great attention to meteorology. I can only give an impression in answer to the question, and my impression is that if the British Government took it up in a broad way, other nations would gladly confer with them in order to establish something like a system throughout the world.

10,340. Could observations for meteorological purposes be well combined with those which you have recommended for the study of physical astronomy?—That is a very difficult question indeed, and one which I feel great hesitation in giving a positive opinion upon. It does not necessarily follow that they should be the same establishments, provided that the results of the two establishments, supposing them to be separate, were thoroughly interchangeable, and that the one observatory communicated its results to the other. I am rather inclined myself to recommend that they should be connected, because the relation of the one to the other is so clear that I think the matter could only be treated well, as a whole, by being under the supervision of one head. I incline myself to think that the central stations for meteorology should be a portion of the observatories for astronomical physics; but besides those central stations there would require to be scattered all over the country a great number of subordinate stations in which celestial physics would not need to be cultivated.

10,341. You are of opinion, are you not, that magnetic observations might be conducted at the same establishments?—Yes, I think so, on the same ground. I think that they are quite out of place as connected with an astronomical observatory. It is easy to understand how they got there, because, when magnetism and meteorology were first systematically cultivated, as far as they have been systematically cultivated, it was natural to turn about to see what observers could be found on whom reliance could be placed, and at that time there existed nothing in the shape of an observing organization except at astronomical observatories, and it was quite natural that they should be attached to those observatories, but I think they are quite out of place there now. I should relieve Greenwich, for instance, entirely of the magnetism and the meteorology, and relegate those researches to the physical department of astronomy. In saying that, I should be very sorry to be supposed to imply that Greenwich does not execute its work well; it is as well executed there as it could be, but I think it is not in its proper place.

10,342. (*Dr. Sharpey.*) I think you said that the work of the Meteorological Office is of too purely observational, and not sufficiently experimental?—Yes.

10,343. What description of experimental work do you think they should carry on?—I will try to illustrate that. I should say experiments, for instance, on the humidity of the air and on evaporation; experiments of that class I think are a great deal wanted. It may be in the recollection of the Commission that some rather remarkable papers were published in "Nature" by Dr. Balfour Stewart, suggesting that a *cordon*, as I think he called it, should include a certain area in which the movement of the air should be tested. That was a very original suggestion of his, and that is the sort of experiment that I allude to. I may here say that some experiments have been recently conducted by a private individual, Mr. Dines, who is known favourably to science as an active member of the Meteorological Society, and he has read papers at the Royal Society also. That gentleman has been engaged for some time upon a course of experiments upon evaporation, and they have brought out results apparently not consistent with what has hitherto been accepted, indicating that the subject is one which should be pursued farther.

10,344. Are you aware that a certain appropriation of money from the Government grant was made by the Royal Society to two gentlemen, Mr. Field and Mr. Symons, for conducting experiments on evaporation?—Yes, and they are much wanted, I believe.

10,345. (*Professor Stokes.*) You enumerated a little while ago the observatories which are under the control of the Meteorological Department, and amongst them was Kew as the central observatory; are you of opinion that it is important that the body superintending that system of meteorological observations should have under their own control some easily accessible station at which actual observations are carried out according to the system by which they are carried out elsewhere, or do you think that it would suffice that the head station should be a head station merely for purposes of superintendence, and that if observations were carried on at a neighbouring place under a different department altogether those could be made use of and combined with the other observations of the system?—I do not know that a central station is a necessity. This governing body to which I have objected exists in London, and they cannot be expected to travel over the country. I think under that arrangement it would be convenient that there should be a typical observatory close at hand, that they may see the working and so judge as to the directions which should be given regarding the other more distant observatories, which are regularly visited, I believe, and inspected by Mr. Scott, the head of the office, under the instructions of the governing body, that governing body basing its instructions, no doubt, upon what it sees of the operations of the Kew Observatory. I think that as the system exists that is a convenience, but otherwise I do not know that it would be necessary.

10,346. On whom do you think that the responsibility rests of the mode of expenditure of the funds which the Government grants for meteorological purposes?—I conclude that the responsibility rests with the committee. I have no official information on the fact, but I conclude that it does.

10,347. But to whom do you conceive that the committee are responsible?—To the Government, through the Board of Trade.

10,348. Not in any way to the Royal Society?—No; the Royal Society as a body are totally divested of all responsibility, and I am glad to say that, being a fellow of the Royal Society.

10,349. (*Professor Smith.*) Does your objection to a governing body extend to such a body as the Board of Visitors of the Greenwich Observatory?—It does. I do not think that that is the best arrangement, but in the case of the Greenwich Observatory it certainly works well; but there is no interference, as I called it, whatever: the Board of Visitors do not superintend, Mr. Airy, the Astronomer Royal's observations; he is left, so far as I know, practically, entirely to carry out his own views in all matters of administration and detail, and the Board of Visitors, I believe, assemble only once a year, and receive his report, and I con-

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

clude, although I have not been present at their meetings and can have no knowledge, that they discuss with him any suggestions that they may have to make, or that he himself may have to make, but they do not govern the Observatory, and they cannot be called the governing body of the Observatory at all. They are a medium of communication and a medium of suggestion between the Astronomer Royal and the Admiralty under whom Greenwich Observatory is placed. For my part, to answer the question fully, I do not think that they are necessary. I think it would be quite sufficient that, having appointed a great astronomer, a man of pre-eminent talent in astronomy, who always would be placed there, I conclude, his responsibility should be direct; but that opens a still wider ques- to which we shall come presently; namely, that he would then have to report to a department that knows nothing about astronomy.

10,350. (*Chairman.*) The next subject to which you refer in the heads of your evidence is that of physics. I believe there is at present no State physical laboratory in this country?—None supported by the State.

10,351. Is there not to some extent one connected with the School of Mines in Jermyn Street?—In a very limited sense, nothing that can be called a State laboratory.

10,352. Do you think that such a laboratory is greatly needed?—I think it is an absolute necessity on the ground of my second postulate, in which I say that all science should be cultivated, even branches of science which do not appear to promise immediate advantage. It is one of the most important parts of science, and cannot be omitted without detriment to all the other parts.

10,353. Do you go so far as to say that all branches of science should be taken under the protection or encouragement of the Government?—Yes, all branches.

10,354. Do you think that they could not be sufficiently prosecuted either by private individuals or by other bodies?—I think not.

10,355. Can you refer specially to any objects for which you think it is desirable that a State physical laboratory should be established?—Investigations connected with almost the whole of our material economy are required. There is no question connected with sanitary improvement, with water supply, or sewage, or telegraphy, or the enormous number of the requirements of the army and navy, which would not derive advantage more or less from investigations of a physical nature such as would be conducted in a physical laboratory. I think that the whole of our naval and military and social economy is dependent upon investigations such as would be carried on in a physical laboratory.

10,356. Do you think that such a laboratory should be a special establishment, or could it be connected with any other Government institution? We have not yet come to the question of chemistry, but it would be quite in place here to say that the severance of chemistry from physics is quite artificial; in fact, the whole subdivision of science into different branches is artificial. Science is the study of the whole. It might be found convenient, certainly, to have the two classes of laboratories associated, but it would be found, practically, that the persons who were best fitted to conduct a chemical laboratory would not be the persons best fitted to conduct a physical laboratory, and on the principle of responsibility, which I look upon as the principle which should never be lost sight of, it would be necessary to separate the responsibility for chemistry from that for physics, so that I think they should be two distinct institutions, however locally associated. It would be very convenient indeed to have them locally associated, because there are many investigations of which one can hardly say whether they are chemical or physical, and the administrators of such institutions would no doubt co-operate in such matters; therefore it would be very convenient to have them locally associated, but, administratively, I think they should be separate.

10,357. Could all the branches of physics, in your opinion, be conveniently placed under one direction, excluding chemistry?—I think so.

10,358. It is not too wide a subject or collection of subjects?—At present, I think that would be sufficient. I may here say that the recommendations which I have made in my précis must be considered merely as a nucleus. I do not think that it would be a final arrangement. There would be a tendency to growth, certainly.

10,359. Would such an establishment as you recommend with respect to physics require, in your opinion, a large staff to conduct it properly?—I should think it would be a large establishment, the variety of subjects that would come before it being very great indeed. I should look upon it as a place at which all inquiries, such as those which have been conducted hitherto in an independent sort of separate manner, should be made. I may mention experiments with regard to projectiles and great guns. Subjects of that sort are very enormous subjects, requiring a great deal of labour, and, of course, involving a great deal of supervision. I think it would be an extensive establishment if it were thoroughly efficient. A great deal of what is now being done in a scattered way, experiments carried on under temporary committees, and so on, would be referred to it. For instance, the experiments carried on under the Ordnance Select Committee, and many others that have existed of recent years, all that kind of work, I think, would be absorbed by the State institution, if it existed, so that although it would be very extensive, the whole extent would not be additional.

10,360. So far as I understand, you do not propose that such an establishment should be for educational purposes?—No.

10,361. But solely for observation and research?—Solely for scientific work. I look upon science, as we are at present discussing it, as a matter of business, to be conducted on business principles, and to be considered as work that has to be done, and I have expressed a very strong opinion upon the subject; it is one of the opinions on which my mind is convinced that nothing is so wasteful as to employ men highly distinguished for their capacity for investigation in teaching the elements of knowledge. I call that a positively criminal waste of intellect.

10,362. Is it your view that in such a physical laboratory as you have described, only investigations on behalf of the various departments of the government should be conducted?—No, that would not be sufficient in my opinion. I rather think that hereafter I have touched upon that, but perhaps the present would be a very convenient time for saying what I have to say upon the subject. In a letter which I addressed to the committee of the British Association, of which I was chairman, dated 1869, I stated what I conceived in general terms to be the duties which might devolve upon State laboratories and establishments of that kind. As chairman of the committee, it was expected from me that I should lay before them some sort of scheme of the organisation, to consider which the committee was formed. In consequence of a paper which I read at Norwich to the British Association, calling attention to the necessity for greater State activity in the matter of science, a committee was formed to consider that subject, and therefore it seemed to be my duty to lay before the committee some sketch of what I thought was needed, and I did so; and I will here give an answer to the question which has just been put to me as to what I thought would be the duty to be performed by such institutions, by reading an extract from my letter. "(First), "To carry out any researches or inquiries required "for the direct purposes of the State, such as, for "example, investigations into the qualities of iron "for naval and military purposes, forms of projectiles, "properties of explosive materials; and when the "State assumes charge of the national telegraphs

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

" (since effected), all matters connected with the ad-" vance of telegraphy, questions also relating to " sanitary and social progress would naturally be " referred to such departments. (Second), To carry " on original research. (Third), To conduct, or assist " in conducting, investigations proposed by individuals " whose unassisted means might be insufficient for " the purpose. (Fourth), To give instruction in the " advanced branches of scientific research to a small " class of students whose elementary attainments had " been attested by the various universities, or other " competent authority. Such students to have a " prior claim to State scientific employment, and, in " fact, to form the source whence to draw the necessary " supply of assistants in the different scientific depart-" ments. (Fifth), To give public lectures." To the above I would now add, in explanation of the fourth head, that I by no means intend that any considerable portion of the time of the directors of these institutions should be consumed in teaching. That should be most carefully avoided, as interfering with their higher duties as investigators. At present, science suffers immensely from this very cause, numbers of our most eminent investigators having to earn their livelihood by conveying year after year the same elementary knowledge to mere beginners, a routine thraldom which cuts off their opportunity, and impairs their powers, of research. The students I speak of should be few in number, advanced in knowledge, and selected for their aptitude for observation or experiment. They would take part in the duties of the observatory or laboratory, and by that means both acquire instruction themselves and contribute to the progress of the work. Teaching of this kind would, I believe, benefit the teacher equally with the taught. The appointment of laboratory or observatory students should be made an object of high and honourable distinction, the reward of great acquirements. I would more fully answer the question by saying that I look upon it as one of the very great objects to be attained by the establishment of such institutions that there should be some place, with proper appliances and attendance and help, in which men of science might be permitted, under due regulation, to conduct investigations, suggested by themselves, which their own means did not permit them to conduct. It is a principle, I believe, by no means new, but a principle which has been adopted on the continent, and I look upon that as one of the most useful purposes to which such institutions could be put. It is one of the greatest wants of the day. We sometimes find, but very rarely, the three necessary elements combined, of ability, inclination, and means to carry on scientific researches. And when we find them combined in an individual, as, for example, in the late Earl of Rosse, or in Mr. De La Rue, and others who might be named, we find a person who is of the greatest value to society, but such persons are necessarily very rare; it is quite an exceptional case in which those three essentials are combined in one individual. On the other hand, we frequently find men of the strongest inclination to work at science, and with great abilities for working, but destitute of means; the number of such persons in England is enormous, and the advantage of assisting such individuals should be very steadily kept in view, and an institution that did not profess to help them would, I think, be very far from complete—it is one of the most important functions of such an institution.

10,363. (*Professor Smith.*) You would allow, under proper regulations, researches to be carried on in the laboratory by other persons besides those attached to its staff?—Precisely so.

10,364. You are of opinion, are you not, that such assistance is, in the case of physical researches, very often of the greatest necessity to men desirous of carrying on scientific research, on account of the expensiveness of the apparatus which is required?—Yes, there may be particular special investigations which could not be carried on without enormously expensive apparatus, which apparatus might be very useful in other investigations besides that special investigation, and it would be an evident waste of money, even if the person possessed the money, for him to spend it upon such apparatus. It would be a question of economy, whether it would be worth while to erect a great steam engine, we will say, driving tremendous hydraulic engines, or anything of that kind, to conduct a special investigation; it would be wasteful to do so, and very few people would do it, whereas means and appliances of that sort are of very general utility, and, therefore, it would be economical to keep them at hand for special investigations.

10,365. Are you of opinion that there would be no difficulty of administration connected with the permission to be accorded, under proper conditions, to scientific men to carry on researches of their own in a national laboratory?—I think there would be a difficulty. I think that in every step in every proposal that I have made, or which I shall have the honour of making, there would be great difficulty, and I should be very sorry indeed to have it supposed that I think it is a simple matter. I think it is an excessively difficult matter from beginning to end, and that would certainly be one difficulty. If this function of such institutions were kept in view when the institution was founded, the building and the appliances, and so on, would be designed for the special object of assisting in those cases, and it would be one of the difficulties to be got over. Then there would be the personal difficulties, the clashings, and so on, which would take place, whatever we do, I am afraid; but the difficulties are in no proportion to the advantages. It is hardly right to call it a difficulty, but one of the requirements is that there should be a body capable of issuing credentials to the men of science who should have those advantages placed at their disposal; no such body exists at present.

10,366. Do you think it absolutely necessary that the ground intended for experiments upon ordnance and explosives and defensive appliances should be immediately adjacent to, or, indeed, at all connected with, a great physical laboratory intended for general purposes?—Your question points to the difficulty of congregating such vast operations under one roof, as it were. I do not think that would be either necessary or possible, for instance, if you had a physical laboratory in the midst of London, you could not have experiments on the perforation of iron plates; that would have to be carried on elsewhere, but probably under the direction of the head of such a laboratory.

10,367. Do you think it will be necessary for a great general physical laboratory to be placed in the centre of London or in London at all, considering the requirements of ground which you have referred to?—I would give rather a general answer to that question. I have enumerated in my précis a number of institutions which I think should be founded, and I think that they should be fixed as near London as possible, but I am by no means of opinion that they comprise all that is wanted. I mean those institutions to be a nucleus. I believe that it will be necessary to have branches of those institutions in different parts of the country, whether branches of them or separate institutions is a matter of administrative detail. I do not think that ultimately, when we find the great advantages of such places, we shall be satisfied with one chemical laboratory and one physical laboratory. It is probable, if the thing is successful—and I feel confident it would be—that in all parts of the country there would have to be other institutions in the great centres of industry. My recommendation is that, in the first instance, the first of those institutions should be founded as near London as possible, not in London necessarily at all, because land is so difficult to get that it is almost prohibitory.

10,368. (*Dr. Sharpey.*) I presume you would not contemplate that the institution of a public physical laboratory of this kind, affording opportunities to private persons for carrying on research, would supersede the expediency of giving special grants to individuals who have the convenience for carrying on researches in their own establishments?—No, I do not.

10,369. Have you considered at all the expediency

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

of aiding existing institutions, such as universities, colleges, and other establishments principally intended for instruction, but where original research in science is carried on. Do you consider that it would still be expedient, where it was shown to be advantageous for the advancement of science, to grant to such institutions aid from the State?—I think so, most decidedly. I should think that it was right to grant aid to anybody who could contribute to the extension of scientific knowledge.

10,370. And also to new establishments?—Yes, certainly. When an application came from a body of that kind, supposing it were an university, the application would be canvassed, and it would have to be shown, first, that the object was a good one, and, secondly, that it could not be carried on without this aid.

10,371. You are aware, are you not, that there are existing establishments in which difficulty arises from want of space, want of building, want of apparatus (and of course all that resolves itself into want of money), but where there is sufficient ability and energy to carry on researches if those difficulties were overcome?—Yes.

10,372. Do you not think that it would be a very proper duty of the State to aid such institutions?—I think so most decidedly. With regard to this branch of the subject there are many individuals who are living in remote parts of the kingdom, who could not come to London, who are carrying on experiments. Possibly their experiments might not require very extensive apparatus, but a certain limited grant would enable them to do very good service, as is now done by means of the Government grant. That grant is a great deal too limited (I shall come to that afterwards), but the principle of that Government grant I look upon as excellent, with a view to what you indicate.

10,373. I presume also that a large central laboratory might occasionally furnish apparatus?—Yes, certainly; the aid should be given in any manner that it could be given, either by funds, or by advice, or apparatus, or in any way.

10,374. It should be a central place to which application might be made?—Yes; at present there is no place to which application could be made.

10,375. (*Professor Stokes.*) The physical laboratory of research which you contemplate would, I presume, be under the direction of a paid head?—Yes.

10,376. Do you contemplate that the work for which he is paid is the superintendence of the work of others in that laboratory, or that he is to work himself at original research?—I should say this, that his primary duty would be, first, to execute any researches required for State purposes, clearly defined researches, and he would then have imposed upon him the moral duty (for I think it can hardly be made more definite than that) of employing the apparatus and any establishment at his command in carrying on original research for ulterior purposes not specially defined, but if the machinery is made complete there would be a body which would suggest to him researches independently of those required for solving problems of the day, such as, for instance, somebody coming forward with a new proposal for an explosive, it would be a matter of official duty to go into that; but if the machinery is complete there would exist a body which would look beyond the requirements of the day and which would foresee that science would be benefited by the carrying on of a particular line of research without any immediate object, but merely that there was a hiatus in science which required to be filled up, the determination of some constant, we will say, or something of that sort, and such a body would be competent to assign work of that kind to the director. With respect to the superintendence of those private individuals who were to work in the laboratory, of course, his duty would be to afford them all the aid which his establishment would admit of, and any advice that he could give them.

10,377. Do you think that original research is carried on as zealously when it is undertaken at the command of another as when it is something that the person himself who carries it on is greatly interested about?—That is a very difficult question I am aware, and one which I have discussed a great deal, and I have heard the remark made that you cannot pay a man to discover. I quite admit that you cannot pay a man to discover, but you may put him in a position favourable for discovery.

10,378. (*Dr. Sharpey.*) You may pay him to determine?—Yes, to determine, or to measure, or to perform definite operations of that kind; but to pay a man to discover is the next thing to talking nonsense, I think. But we have an example ready to our hand, and an answer to that very question, and I am quite surprised that those who have occasionally put it to me as quite an irresistible argument against my views have not seen it. The Royal Institution has a well-equipped laboratory over which presides a man selected for his eminence in science. We know quite well that discoveries have been made there by Davy, Faraday, and others, and by its present head, Professor Tyndall; more than that the State cannot be expected to do—but that a private body does already.

10,379. (*Professor Huxley.*) But is the Board of Managers at the Royal Institution to instruct the professor as to the direction that his researches should take?—No, I conclude not.

10,380. The Board of Managers surely has never given the smallest indication either to Young, or to Faraday, or to Tyndall, what he should do?—No; I think that remark is a very just one, and I think that anything of that sort should be done with very great caution, that it should not amount to a direction; it should only amount to a suggestion, and it is rather anticipating what would naturally follow; but according to my idea of the scheme, the directors of those institutions should be members of a body which I think should give them suggestions. It should not be a body independent of them, but according to my scheme they would be essentially components of the directing body, which I think would make that difficulty less.

10,381. (*Chairman.*) There is a Government establishment for the direction of national standards, can you give the Commission any information with respect to that establishment?—It is situated next door to this building, and if I might be allowed to make a suggestion, there is no institution better worth a visit by the Commission than that. It is one that I think they would be glad to know the exact condition of. It is of recent creation, or, perhaps, I should say growth. I fancy that an office of that kind has existed from time immemorial almost, but it has received very great development within quite a recent period. Since I returned from India, in fact, when I once paid it a visit in order to obtain some information, I think about six or seven years ago, it was very meanly equipped indeed; they were almost without comparing apparatus, and they had no apparatus of any importance at all, but under the fostering influence of the Commission, the head of which is the Astronomer Royal, and under Mr. Chisholm's very admirable administration, the Warden of the Standards, it has become an institution of very great extent and importance. It now possesses a very large amount of valuable apparatus for its purposes, and the only objection that I see to it is a local one. I do not believe that the Commission itself, or Mr. Chisholm, the Warden of the Standards, would quite agree with me in saying it was an objection, namely, that the building in which it is situated is not specially designed for scientific purposes. It has been very ably altered and made as suitable as the circumstances would admit, but still I do not think that a place of that kind can be obtained by converting a dwelling house into a laboratory, and in that respect I think it admits of improvement, but otherwise it is exceedingly complete for its present limited purposes, for they are limited, and it is exceedingly well conducted. I would instance, with regard to the building, a house erected under the directions of Sir Henry James, the head of the Ordnance Survey at Southampton, of which the immediate object was to effect intercomparisons of all the linear standards of Europe, in order to enable the great arc of longitude, which has its origin I think somewhere in the Ural mountains and its termination at Valentia, passing through a number of different countries, all using different units of length, to be reduced and combined into one harmonious whole, and for this purpose all the linear standards of these different nations were sent to Southampton to be compared with the British standards and with each other, and to admit of that being done a peculiar building was erected, which is double, it is one room within another, with thick walls and a certain space between the two walls. The roof is double and the walls are double throughout, the object being to diminish the rapidity of the changes of temperature, and there, so far as I understand, and I have visited it frequently, the control of the temperature is as great probably as it is possible to obtain. There has been a full report upon those experiments and a description of the building by the Ordnance Survey, and its title is "Comparison of Standards;" it is a volume of the Ordnance Survey series, and it is exceedingly well drawn up by Captain Clarke of the Ordnance Survey. The experiments made there are identical with many of the experiments made next door. And I have no doubt in my own mind that the building at Southampton is better adapted for the purpose than the one in London possibly can be; still every precaution is taken here, no doubt, and I believe that the authorities are satisfied with it, although I cannot say that I am quite satisfied with it.

10,382. Does this establishment next door to us find constant work to do?—This establishment has I believe a great deal of work.

10,383. I suppose it is only a small establishment?—It is a very considerable establishment. I am not sure about the number of persons employed in it, perhaps it is not a very large number of persons, but the extent of room and the quantity of apparatus are very considerable.

10,384. And you believe that there is considerable work for it to do?—I think so.

10,385. What is the nature of its work?—The nature of its work is to maintain in their integrity the three units of length, weight, and capacity. And it appears that there is no such thing as finality in such work. There is no such thing as making a standard of measure or of length, and locking it up, and saying, There, that work is done, now we need never look at it again. It needs constant revision and constant examination of a very delicate nature indeed; and there is a great deal of work of that kind, and, moreover, the work consists in creating the means of doing such work. The demands of science have become so much more refined of late years that what would have been put up with 20 or 30 years ago is no longer deemed sufficient, and, therefore, they are constantly improving their system, and becoming more or less, as I think all of those establishments must do, experimental, but all the work that they do is of a purely official character, I believe, at present. I would here suggest that more exact information might be obtained from Mr. Chisholm himself, and no person in England is more competent to give it, regarding that establishment. I think that their work is very much confined to the maintenance of these standards, for commercial purposes, and so on, but I do not think that that is all that they should do.

10,386. (*Dr. Sharpey.*) Do they make copies?—No, they do not make copies, they verify copies, but only for certain bodies. It is a very important point. I believe by the present powers (they possess Parliamentary powers) they can only verify standards for certain public bodies. I am not sure what that term includes exactly, but that is the general scope of their powers in that respect, and that in my opinion is not sufficient. In the same way that I have recommended that private individuals should have access to, and the aid of, laboratories, so I would wish to see private persons engaged in scientific researches able to go to to an institution like this, to obtain the verification of standards, which I believe now is not possible to be done, for a kind of technical reason, as I have understood, namely, that they have not the power of demanding fees, and that, therefore, they would not have funds, without such fees, for paying the establishment that would be necessary to carry on those verifications. I believe that is how the matter stands, but I believe the question has not been lost sight of at all by the Commission; and I was given to understand some time ago that it is to be made the subject of some representation; it is very much required. I can speak to that in my capacity as regulating the instruments supply of India, in which a question of this sort occasionally comes before me. When I took charge of my present office I found very great errors existing amongst opticians, in respect of the linear unit, chiefly owing I believe to there being no place to which they could go and get verifications. I found in the scales of barometers made for me by one of the best firms in London that there was an error of unit (all the instruments being alike, thus proving it to be an error of unit), amounting to nearly the 100th part of an inch in each foot, which was simply barbarous. There is no other expression for it. Therefore, I think that if this institution had powers and appliances for assisting science in that way it would do a great deal of good.

10,387. (*Chairman.*) Are we to understand that no private person has any means of ascertaining, if he is desirous to do so, whether his measures of any kind are correct or not?—I believe not, except as a matter of private favour. I think not at all, as a matter of right.

10,388. (*Dr. Sharpey.*) Of course, for commercial purposes, there are secondary standards deposited throughout the country at various headquarters where comparisons are made by the proper officers?—Yes, there are. But I understand that the local officers are subject to local authorities, such as town councils, magistrates, &c., necessarily unscientific, and that they cannot be legally controlled by the London office, which is scientific. This is one of the thousand instances of disregard of system in our present scientific arrangements. There was a large number made when the new Exchequer yard was constructed, owing to the old one having been burnt in the Houses of Parliament. When that was constructed a very large number of secondary standards were made and they were distributed to the Universities and to foreign governments and societies, and so on, but they are of no use without appliances for verification.

10,389. (*Chairman.*) Are you of opinion that this establishment requires additional apparatus of any kind?—I will mention how that matter stands. Before the Kew Committee of the British Association ceased to exist, that is to say, before the Kew Observatory was given up by the British Association, I was a member of that Committee, and there came before us on one occasion a letter from the Standards Commission next door, requesting us to supply an accurate thermometer for their very refined purposes. It became a question of great importance for us to discuss, and accordingly we discussed it very carefully, and on being called upon personally by the chairman, Mr. Gassiot, to give my opinion upon the subject, I stated this: that assuming—which I did not admit—but assuming for the sake of argument that the two points of the thermometer known as the fixed points, that is, the freezing point and the boiling point, assuming those to be fixed according to the present processes with sufficient accuracy, or to be made with all necessary care and precaution known hitherto, there would still remain this question, what would be the effect on the points intermediate to those produced by a difference in the expansion between the glass of which an individual thermometer was made and the mercury in it. Now the glass must be taken in all thermometers as different in each case, and this

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

difference of expansion is not provided for at all by the processes which determine the fixed points, and is, in fact, left undetermined. I therefore said, that as, by Act of Parliament, the temperature of the linear standard of Great Britain was fixed, very unfortunately, I think, at 62°, that was a point which no existing thermometer in Great Britain could pretend to determine accurately; and I, therefore, recommended that the reply to the Standards Commission should be to that effect; that whilst we should guarantee the fixed points according to the processes employed, and guarantee the care in the execution of the thermometers and the calibration of them, still we could not guarantee the accuracy of the intermediate points. That letter was written and is now accessible to this Commission, if they wish to satisfy themselves, by referring to the establishment next door, where it is no doubt recorded. It was a distinct definite declaration on the part of a scientific body, that there existed in England no standard thermometer.

10,390. Is the same the case with respect to the barometer?—The barometer is not so important, but, of course, it is important because the standard is expressed in terms of pressure as well as of temperature; but still it would require a larger error in the barometer to produce a sensible effect than in the thermometer. In consequence of that declaration from the Kew Committee on the subject, I am told that the Commission took into consideration whether they would not obtain an apparatus, I believe first contrived by Mr. Regnault, of Paris, and known as the air thermometer, by means of which those intermediate points could be rigorously determined. Recently I paid a visit to the Standards Commission office and enquired if this had been done, and I was told that the cost of such an apparatus being about 200*l.* it was considered too much to pay for such a purpose, and it was not done. Therefore, there exists still no standard thermometer in England, and there exists no standard of length accurate in the terms of the Act of Parliament; up to a very recent period, within the last three or four months, I was told by Mr. Chisholm that it had not been done.

10,391. Under what department of the Government is the National Standards Establishment?—It is under the Board of Trade. I might here remark, as part of my answer to that question, that there could not be a more absurd location for the department, for trade is not the department to regulate niceties like these, it is necessarily quite incompetent to do so, it might as well be under the Home Department, or under the Admiralty, or the War Office, or any other department, as the Board of Trade. I should mention that my office of inspector of scientific instruments did not exist before my appointment. I was the first occupant of that office, and, therefore, I had to create it entirely, and amongst other things I required standard barometers and thermometers to regulate the accuracy of such instruments for India. I obtained well made instruments of that kind and then sent them to the two only existing institutions which contained the professed standards, namely, Greenwich and Kew, to be compared. And I found that the comparisons were discordant, that is to say, that Greenwich said that the thermometer and barometer had such and such errors, and that Kew said that they had different ones. This being very unsatisfactory I addressed the Royal Society on that question. I was at that time a member of the council, but on the eve of retirement by rotation I addressed the Royal Society on the question. And I was fortified by the opinions not only of independent men of science, but of the directors of those two institutions, Mr. Airy and Professor Balfour Stewart, who were then the heads, and they both agreed with me that the enquiry was one deserving of the attention of the Royal Society and if the Commission will allow me I will place in their hands their printed letters (*delivering in the same*). There are letters from Mr. Airy, from Dr. Balfour Stewart, from Professor Clark Maxwell, and from Sir William Thomson. I applied to them as being the highest authorities as I thought in England, and they all agreed with me that this enquiry was one that ought to be made. I shall only briefly say that the Council of the Royal Society did not see fit to undertake the enquiry. I made three distinct applications on the subject, and they were all three declined, the first with reasons given which led to my addressing those gentlemen; the second, I think, with very few reasons if any, and the third I think with none, but simply a refusal conveyed in courteous terms to grant the committee which I had asked for, and so the matter ended. The Royal Society is not on its trial here, and I do not wish to make any reflections upon it, but my personal opinion is that it was an enquiry that the Royal Society might and should have undertaken. It is one that had on a former occasion been undertaken by the Royal Society, and was strictly within their functions. I shall say no more upon that point, but I wish to say this, that it has been sometimes suggested to me that the Royal Society is a body already in existence which might very well be constituted a standing adviser to the Government on all scientific questions. I think that this circumstance which I have spoken of shows that it is not a body qualified for such a purpose. Being a private and in no sense an official body it would or would not undertake enquiries as it saw fit. That will not do for business arrangements, and I am talking of science as a matter of business. Moreover, the amount of work that would be entailed upon any body affecting to be the advisers of the Government on science would be so enormous that no private individuals could be expected to perform it. But this little occurrence indicates, I think, that the Royal Society is not a body that should be counted upon for such purposes.

10,392. (*Professor Stokes.*) Could you mention the reasons which were put forward by the Royal Society?—I have them here. I have mislaid the two later resolutions, but I have here the letter of the secretary and the minute of Council.

10,393. Was the report of the Committee communicated to you?—Yes; it is headed "Report of the Committee"; it is enclosed in a letter dated the 17th December 1869 from the Secretary of the Royal Society, and it is in these terms:—"The Committee “ appointed 28th October 1869 to advise the Council “ as to the course it may be expedient to take in regard “ to Colonel Strange's letter to the President, beg “ leave to lay before the Council the following report: “ —The object of Colonel Strange appears to be to “ obtain an authoritative declaration that a particular “ barometer and a particular thermometer shall be the “ standards of the respective instruments. With re- “ ference to the propriety of taking such a step, it is “ important to observe that the case differs altogether “ from that of standards of length and weight. These “ are essentially arbitrary (for any absolute determi- “ nation with reference to a natural constant is liable to “ greater error than the comparison of two measures “ of length or weight), whereas the height of a baro- “ meter and the reading of a thermometer are essen- “ tially referred to natural constants, and a standard “ instrument of either kind should be made directly, “ not by copying another instrument. The accuracy “ with which such instruments are executed will “ depend on the care bestowed on their construction, “ and a continually increasing approach to absolute “ exactness may be expected to accompany the pro- “ gress of science. If any person wishes to refer to “ an instrument of either kind as a standard the re- “ sponsibility must rest with him to choose that which “ he considers best. In the present instance if Colonel “ Strange is not satisfied with the degree of accordance “ of the instruments at Greenwich and Kew, it will be “ for him to employ whichever he considers the more “ trustworthy. The Committee think that the Council “ might properly suggest to Colonel Strange to lay “ copies of his letter before the Astronomer Royal and “ Mr. Balfour Stewart," (that is what induced me to write to them) "which might possibly result in detect-

" ing the cause of the small discrepancies which Colonel " Strange has pointed out; or, if otherwise, might " furnish Colonel Strange with additional data on " which to base whatever decision he may arrive at. " The Committee do not recommend the Council to " appoint a committee of the Royal Society for the " purpose of considering the subject of national baro- " metrical and thermometrical standards." That report did not satisfy me at all. It seemed to indicate that there existed no such thing, and that there never need exist such a thing as an authoritative national standard, and it left me, a State official, to create my own authority. Now that is a responsibility which should not devolve upon me. I think, as a State official requiring a certain fundamental element, that I should have been able to turn to some authority established by the State to give me that element; and one of my indirect objects in making this representation to the Royal Society was to fix clearly the fact that there existed no such authority in England. That was one of my indirect objects, and it had a bearing upon this question which we are now considering. I did not wish to impose upon the Royal Society the responsibility of making a standard, but I thought that the inquiry, if they had undertaken it, would have led to a clear exhibition of our deficiency in this respect, which is only one of a thousand, and I did not think it was at all a satisfactory state of things that I should be left to take one of two differing instruments which, by reason of that difference, were neither of them entitled to be considered as authorities. The fact that the two things differed was against both.

10,394. (*Dr. Sharpey.*) Might you not have applied to the heads of your own department, and have stated that you, as a public functionary, had found a difficulty in making the required comparisons, and it was desirable that some action should be taken in the matter. In that case the Government might probably have moved the Royal Society to make the inquiry; and if they had refused, then it might have been said that they were not a body to be consulted?—It is possible; but in doing so I should have had to tell the India Council that there really was no institution on whom could devolve such a duty. The first thing to ascertain was what was wanted. I only asked the Royal Society in my final application to inform me what was wanted, who should do it, and what it would cost. If the Royal Society had been so condescending as to give me that information, I would have gone with it to the Government if they would not; but I was stopped, and I have no standard, nor has anybody else.

10,395. (*Professor Smith.*) You mean that there is no such standard in existence, not only in this country, but also on the continent?—That may be so. I cannot say of my own knowledge how the matter stands abroad; but if not, I can only say that there ought to be.

10,396. (*Dr. Sharpey.*) Did I rightly understand you to say that the Royal Society had on a former occasion undertaken to make a standard barometer?—No; I did not intend to say that. I will refer to one of my letters to the Royal Society, which will state exactly what they did. In this letter to the Secretary of the Royal Society, dated the 2nd of May 1870, I say, " The very subject to which I am now asking the " attention of the Council underwent discussion and " practical investigation by the Royal Society nearly " one hundred years ago" (I referred to the volume expressly before writing this), " when a committee, " comprising the distinguished names of Cavendish, " Heberden, Aubert, De Luc, Maskelyne, Horsley, " and Planta, reported to the Royal Society in June " 1777" (these are the *ipsissima verba*), "on 'the " 'best mode of adjusting the fixed points of thermo- " 'meters.' I have carefully reperused this admirable " document, which records a series of delicate and " laborious experiments; and I am bound to say that " we have scarcely made any advance, in the lapse of " a century, in the methods recommended by these " great men."

10,397. They did not attempt to fix an authoritative standard?—No; I do not suppose they did.

10,398. The barometer that was made under the direction of Mr. Bailey was for the society's own purpose. At that time the Royal Society kept a record of meteorological observations, and it was solely for that object, was it not?—Yes.

10,399. Since then, you are probably aware, that record has been given up?—Yes, it has; and the barometer no longer exists, or rather not as a barometer.

10,400. Supposing the result of your suggested inquiry had been to produce a barometer which differed both from the Kew and the Greenwich barometer, how could you say which was to be depended upon or which should be the standard; who would settle that point?—That is rather a difficult question to answer, I admit; but it is the very answer that I wanted to extract from the Royal Society. That would have been a very useful argument for me to use in the very inquiries that we are now instituting.

10,401. (*Professor Stokes.*) Is not that pretty nearly the answer which you got? The beginning part of the report says, " The object of Colonel Strange appears " to be to obtain an authoritative declaration that a " particular barometer and a particular thermometer " shall be the standards of the respective instruments;" and the Royal Society were not willing to take the responsibility of making such a declaration?—I think that may be inferred. I do infer it, of course; but I should have liked it to have been expressed positively, and not by inference. I wish to say this, that I bring this before the Royal Commission not in order to ventilate a personal grievance—I hope that I have no such petty object as that—but to point out by a forcible example that we have no institution capable of doing this sort of thing. The requirements are more than that of merely making a standard in those cases. A standard barometer or a standard thermometer is not a standard necessarily from year to year. It requires to be watched and to be experimented with, and fresh copies have to be made to see that no deterioration has taken place; in fact, it is a very delicate experimenting business, which should be continually going on; and it is not sufficient to make to-day a barometer and hang it up on a wall, and a thermometer and lock it up in a drawer, and say, These are the standards; for no human being can say that 10 years afterwards they will give the same indications, and therefore it is more than a constructive task; it is a task requiring continual experiments, just as I have already said the proper conservation of our standards next door is a matter of experiment, and we have no institution capable of doing it.

10,402. You are probably aware that a second barometer has been constructed at the Kew Observatory?—Yes, I am.

10,403. And that the two perfectly agree?—I am aware of that, but that does not prove either to be right; it only proves that the methods employed on both occasions were identical; it does not at all prove that the method was correct in either case. And with regard to the Royal Society, it is a very remarkable fact that Mr. Bailey, in his paper descriptive of his instrument, omits altogether one essential. He does not say how the tube is filled. I studied the paper carefully at the time, and it is a fact that he does not say by what process the tube was filled. There is a foot note from which may be extracted, by a very excruciating process, a sort of distant hint or inference that it was boiled, but the process is not described. It is not categorically stated how that tube was filled. Now that barometer got deranged, and it is no longer in existence as a barometer. But the Greenwich barometer derives its authority from that barometer; and Mr. Airy, in his correspondence with me on that occasion, gave me the whole particulars, which I think I have stated in my letter. And, therefore, any doubt that may attach to the original barometer of the Royal Society, constructed under Mr. Bailey, attaches still to that of the Royal Observatory at Greenwich; and to my mind, unless I know exactly how that was

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

done, I do not recognize the instrument as a barometer for high scientific purposes, any more than I should recognize the bottle on the table.

10,404. (*Professor Huxley.*) Supposing that the institution to which you refer were established, and supposing that they had set up another barometer, on what would the authority of that barometer rest? You would not have a standard by Act of Parliament, would you?—I do not see why you should not, by Act of Parliament, delegate to a particular National Institution the duty of preserving the standard barometer and thermometer, and affording comparisons of them.

10,405. But an Act of Parliament could give no possible scientific value to that barometer; it would still be open to any person wishing for an accurate barometer to take either the Royal Society barometer or the Greenwich Observatory barometer?—I think you would still have the Act of Parliament to define, as it now defines, what constitutes the standard of length.

10,406. Would not that be a very serious piece of legislation to bring before the House of Commons?—It would be perfectly useless, I admit. We want somebody before whom to bring it. Every one of these questions point in one direction.

10,407. (*Professor Stokes.*) An Act of Parliament would have the effect of relieving from responsibility any person who took that as a standard?—You may apply the same reasoning to any standard or to anything.

10,408. The standard of length, for instance, is arbitrary, but a barometer is not arbitrary?—The standard of length is arbitrary, subject to certain conditions, subject, for instance, to the condition that the two terminal points shall be in a horizontal plane. The same argument applies to that, because there are certain conditions that have to be observed in making that a standard, without which it cannot be considered an authority, and those conditions have to be defined, and they are defined.

10,409. But the length is essentially arbitrary?—Yes, the mere length is quite arbitrary; but still that length cannot be transferred to another without the intervention of certain conditions.

10,410. But I presume that the mode of comparison was not laid down by Act of Parliament?—I am rather inclined to think it is. At any rate the temperature and pressure are laid down, and that is quite sufficient to stop us.

10,411. (*Chairman.*) With respect to metallurgy, what is your opinion as to the need existing for the establishment of a metallurgical laboratory by the Government?—It might be said, and I am not at all prepared to contradict such a suggestion, that that might form a portion of, say, the physical laboratory. I do not say that it should, but I think it is a matter of administrative convenience more than anything else, and of the sub-division of labour. I apprehend that the range of work of the physical laboratory would be so enormous that it would be hardly possible for one man to superintend both.

10,412. There is no essential distinction, is there, between the two?—I think not; it is a mere matter of division of labour.

10,413. (*Professor Stokes.*) Do you understand the physical laboratory to comprehend a chemical laboratory?—I think I said before that it was rather a question of the division of labour.

10,414. You would connect the metallurgical laboratory rather with the physical than with the chemical laboratory?—It is very difficult to say to which it belongs; it belongs to both. They are all one subject, in fact. I think, having talked it over a little, that the convenient method would be to have distinct establishments, but situated near each other, so that they might interlace in their operations. The quotation which I make, coming from such an authority as Mr. Anderson, indicates more the chemical than the physical conditions. I may say that I felt it my duty to bring to the notice of the Commission such documents as I possessed officially as chairman of a former committee, which at all bore upon this enquiry, not knowing whether the Commission would call those persons before it or not. I thought it my duty to bring their opinions on certain points forward, and I may here say, referring to that subject, that my committee addressed about 300 persons more or less interested in and connected with science upon that occasion, and we received, I think, about 100 replies to very specific and definite questions, and I do not think that more than ten of our correspondents answered these questions. I think the other 90 went off in any direction that appeared most interesting to themselves, and therefore the number of specific points brought before us was very small, and I thought it my duty to mention some of the most prominent. This coming from Mr. Anderson, who stands quite at the head of that particular branch of engineering, I thought of such value as to deserve record. After recommending that an establishment should be created by the State for physical researches, with one of the best men to be found in the world at the head of it—"A man of the Professor Tyndall stamp," he goes on to say, "to give an instance which is now ripe for the "investigation of such a student, with thousands of "facts ready to his hand on all the completing points, "namely, in regard to cast-iron and steel, and the "natural laws that determine their varied phenomena. "If this subject were thoroughly explored, so that in "practicable operations men could, by simply obeying "or following the laws clearly laid down, obtain with "certainty the high conditions which are sometimes "arrived at in regard to the various properties of "tenacity, density, hardness, softness, malleability, "ductility, elasticity, and so forth; to fulfil this object "the investigation must be exhaustive in regard to "chemical composition, and pointing out simple "means of definitely ascertaining the laws of crystal-"lization as affecting the form or rate of cooling "constituents, combined and uncombined, and all the "numerous other points that are still more obscure. "No price would be too high to pay for such an "addition to the knowledge of this country; it would "in a money consideration be worth millions annually, "and would alter many of our present arrangements." I may add, with regard to a more philosophical use of the metals, that authorities are not yet agreed as to the material most suitable for the construction of fundamental linear standard measures. When the present Exchequer standard yard was being constructed in 1855, Faraday's opinion on this point was sought. His reply was "I do not see any reason why "a pure metal should be particularly free from in-"ternal change of its particles, and on the whole "should rather incline to the hard alloy than to soft "copper, and yet I hardly know why" (*vide* Account of the Construction of the new National Standard of Length, and of its principal Copies, by G. B. Airy, Esq., Astronomer Royal. Read at the Royal Society, 18th June 1857, page 33). I believe we are not any nearer a solution of the question now after an interval of 17 years. Nor is this surprising, since no direct experiments on the subject have been made and our knowledge, such as it is, rests on inference only. No one can answer confidently these two questions: (1) Do changes take place in a lapse of many years in the dimensions or the co-efficient of expansion of masses of metals? and (2) What metals, and obtained by what means of preparation, undergo the smallest changes? This question interested me very much as an officer of the great Trigonometrical Survey of India, with reference to our 10 feet iron standard bar, which constitutes our ultimate linear unit. On returning to England in 1860 I determined to propose the problem for solution by the learned here, but, to my profound surprise and disappointment, I found that there existed in the kingdom no functionary or institution on whom such an inquiry could properly devolve. It was the discovery of this fact that first directed my attention to our national deficiencies with respect to science. There is now an International Commission sitting for the purpose of establishing "prototype metres" as

Lieut.-Col. A. Strange, F.R.S.

24 April 187

proposed by the Imperial Academy of Sciences of St. Petersburg. The material of which these should be constructed is one item of their programme. Each member will probably hold a different opinion upon the subject, and they may as well draw lots as decide it in any other way, for reliable data for the formation of a defensible opinion do not exist. I may give another instance within my own experience. About 10 years ago I was intrusted by the Secretary of State for India with the designing of an extensive series of geodesical instruments of the highest class, for the use of the great Trigonometrical Survey of India. The alloy aluminium bronze attracted my notice as probably suitable for some of my purposes; but I could obtain no reliable data as to some of its properties, such as tenacity, rigidity, co-efficient of expansion, &c.; nor did any institution exist whose services I could claim to solve my difficulties. With the help of Messrs. Troughton and Simms, and of Mr. Anderson at Woolwich, I got some experiments made, and was obliged to act on them, though they were unavoidably of but an approximate order. When it is considered how important a part the alloys play in the useful arts generally, and in the Government workshops, dockyards, &c., and how their properties vary with proportion, purity, and mode of mixing and treating, it seems to me wonderful that no systematic means exist for gaining trustworthy knowledge of such high utilitarian, not to say philosophic, value. I should wish to say here that in quoting the sentence from Faraday's letter, I am by no means intending to reflect upon Faraday. On the contrary, I have frequently spoken of that as an instance of his honesty and candour.

10,415. (*Chairman.*) There is I believe a metallurgical laboratory at the School of Mines at present?—There is one there, but I believe it is on a limited scale. I have no doubt it is very good as far as it goes, as all that department is, but it is anything but sufficient for the objects that I have in view here, and I think it is more concerned in teaching than in experimenting, but, however, I am perhaps not fully informed. I happen to have seen the programme of the International Commission that is now at work upon the prototype standards, and I feel convinced that they will split upon that rock at the outset, they will not know what to make the standards of.

10,416. Do you know what nations are represented in that International Commission?—I think most nations are. Germany I know is, and Russia I know is (it originated with Russia), and England is represented by the Astronomer Royal and Professor Miller of Cambridge, who are both members of this Standards Commission, and I think the Warden also, Mr. Chisholm. I should like to mention that the Prussian General Baeyer, connected with geodesical works in Germany, wrote a paper, which has been translated by the Standards Commission, and which was given to me, and in that paper he asserts that he has found a change in certain standards that have passed through his hands.*

10,417. To a certain degree you have already alluded to the subject of chemistry; you consider that chemistry is one of the objects which should be included in Government institutions?—Yes, it is one of the most important of all.

10,418. There are a larger number, are there not, of existing chemical laboratories than of laboratories of other descriptions?—Yes, there are.

10,419. But you think that they do not accomplish all the objects that are needed?—No, they are not national.

10,420. Do you think in every case a national institution is wanted, whatever work is done by private institutions?—No, I do not think that, but it will be permanent, the work will be done and will go on being done, and there will be a continuity of work. Those are points in which Government establishments are necessarily superior to private ones. But it is quite possible that an individual of wealth might establish a laboratory on a grander scale even than the nation, and might conduct his researches in a more efficient style. I have lately visited a private laboratory of very great extent, which is worthy of being mentioned, although it is not fully organised, that of Lord Lindsay. He has taken the whole of a house in Greek Street, Soho, and it is a very fine laboratory, it has a very large external kind of hall, which was formerly an organ builder's establishment, and it is equipped in a most expensive manner for chemical and electrical experiments. He is now forming what will be the most powerful electrical battery in the world. It will consist of 100 cells, each as high as this table, and the doubt is whether the structure of the house will bear the weight. So that private individuals may do an immense deal, but there is a want of permanence and continuity in all private efforts.

10,421. That scarcely applies to laboratories belonging to the Universities?—No, that does not apply so much to them it is true, but I apprehend that such laboratories have for their chief object instruction, about which I say nothing, and wish to say nothing.

10,422. (*Professor Smith.*) You do not think, so far as assistance to men of science is concerned, that it is quite so necessary in the case of a great number of chemical researches as it is in the case of those that are more commonly called physical?—No, for the reason just given, that there has been, as it seems to me, a greater development of chemical energy than of physical energy in the country.

10,423. Because the appliances are so many and chemical researches are so much less costly?—I dare say that may explain it, and the direct application of chemistry to useful manufacturing purposes is more obvious than that of physics. That may possibly have determined it, but the fact is beyond all doubt.

10,424. Have you any remarks to make upon the subject of Government establishments connected with natural history?—That is a branch of knowledge on which my ignorance is more complete than on many others; and therefore what I say regarding that I say not as from myself, but rather as repeating the opinions that I hear about me. I could not venture to express any decided and positive opinions of my own on a subject which I know so little of as natural history; but I would say this, that natural history is a branch of science the neglect of which would render the whole incomplete, that it is just as indispensable as chemistry or physics, or anything else; and I think that every possible means should be taken of advancing that science and of facilitating the studies of others in it, just as in the case of chemistry or physics. More public money is spent in England in certain departments of natural history than on all other branches of science put together. Not being a naturalist, I have not much to say on the subject. I am told by those conversant with it that our national collections at the British Museum would be greatly enhanced in value if means existed for giving explanation regarding them and for enabling investigators to study them, and that for the latter purpose there should be appropriate rooms and instruments for research, accessible to men of science duly accredited, in the same way that the library is rendered available by means of the reading room to men of letters. It seems also desirable that a certain number of ships of the Royal Navy should carry a staff of naturalists, with every necessary appliance for making collections of natural objects and for observing such natural phenomena as obviously present themselves at sea. The importance of such efforts has been demonstrated recently by Drs. Wyville Thomson, Carpenter, and others. But these efforts have been made under pressure from the Royal Society, and are spasmodic. They should be a regular duty of the naval service, performed continuously and systematically. The First Lord of the Admiralty in his recent speech on the Navy Estimates, on the 21st of March, seems to contemplate some action of this kind.

10,425. (*Professor Huxley.*) In speaking of physics or chemistry, you do not suggest the propriety of making the persons who are entrusted with the charge of

---

* Vide Appendix X. to the Fifth Report of Standards Commission, 1871.

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

the State laboratories in physics or chemistry give lectures; but in natural history do you think it desirable that they should give lectures?—As far as lectures are concerned, I think it would be advisable that all those institutions should convey a certain amount of instruction; but whether those lectures should relate to the results of experiments is one thing, and whether they should be popular lectures or elementary lectures is another. I have not entered into that detail. My present notion is that they should give lectures calculated to inform the public mind as to what is going on in their respective institutions.

10,426. Lectures like those at the College of France, for example?—Yes; more than that, lectures of instruction, and that I should apply to all those institutions.

10,427. Are you practically acquainted with the habits and discipline of the ships of the Royal Navy?—Not intimately.

10,428. Do not you think there would be a little difficulty arising from these circumstances in carrying in any considerable number of ships a staff of naturalists?—When I say I am not acquainted with the organisation of ships of the Royal Navy, I am to a certain extent, of course, acquainted with how they are managed, and that very strict discipline has to be maintained; but I cannot myself see any insuperable difficulty in appointing to a certain number of ships (and you might have the number limited) a staff of naturalists, just as has actually been done at the intervention of the Royal Society, a staff not of naval officers, but a staff of independent men of science have been put on board a ship of the Royal Navy to carry on researches.

10,429. But in that case the ship is detailed for the scientific service and is not a man-of-war?—Yes, I am aware of that.

10,430. In a man-of-war the whole organisation of the crew is directed to one end, which is the efficiency of that ship as a man-of-war. I am very much afraid that a staff of naturalists would be very much in the way in the ship?—Of course their operations must be secondary to the discipline necessary for the ship, but I do not see myself that there should be any difficulty about getting a great amount of work done in that way. The discipline of a man-of-war is of course the first thing that the captain would think of, and rightly so, but so far as is consistent with that discipline, it would be his duty to assist and facilitate the efforts of the men of science appointed to his ship. It might be so managed that if it were found that the discipline of an ordinary man-of-war or an ordinary cruiser would be affected by the addition of this staff of naturalists, or if the staff of naturalists could not do their work well in such a ship, then there should be a sufficient number of ships for exploratory purposes. I think the subject is a sufficiently important one to justify it.

10,431. There would be no difficulty in carrying out your suggestion in those vessels which are detailed for the surveying service, and a number of them are always being employed, but I cannot help thinking that there would be very great practical difficulty in employing for that purpose ships which are detailed for ordinary service?—Yes, I have said ships of the Royal Navy, you see it is a very wide term, that does not necessarily mean great armour clad vessels of war, it would be a question of administrative detail, what ships. All I want is that the ship should be one belonging to the State, and that the naturalists should be persons paid by the State.

10,432. You would attain your object in those ships which are already employed for scientific purposes and surveying purposes, and then your suggestion would not meet with the objection which it would meet with from persons who are acquainted with ships of war?—Yes, that probably would be the best way of doing it. The same ships might be employed in oceanic meteorology, as indicated in my answer to question 10,338.

10,433. (*Chairman.*) Are you prepared with any suggestions on the subject of physiology?—My plea of ignorance of natural history applies with redoubled force to physiology. I am quite content to produce a quotation from Dr. Michael Foster, formerly of the University College and now of Trinity College, Cambridge, and with this further addition that I believe that there is not the slightest novelty in his suggestion. As far as I understand there exist on the continent numerous physiological laboratories. Dr. Foster, in his letter to a Committee of the British Association of which I was chairman, says: "In the matter of appliances for physiological inquiry there is also a lamentable deficiency, and when larger numbers of physiological careers are open this will be increasingly felt. I am strongly of opinion that the importance of the matter is sufficiently great to warrant the employment of State aid, but I do not at present well see how the aid can be given. For the reasons above given I should not advise the creation and endowment of any special institution for the prosecution of physiological inquiry. But the extension of existing institutions by way of endowment of chairs of physiology at certain medical schools with additional funds for apparatus might be well, but I must confess to considerable doubt on the subject. A much more useful way appears to lie in the establishment at some already existing institution, such as at Kew or Jermyn Street, or elsewhere, of a physiological laboratory furnished with costly appliances and intended solely for such researches as can only be carried on by means of such appliances, the right to work in such a laboratory being awarded to special demands by the authority of some scientific body." I give the above as an example of opinions which I have found prevalent amongst physiologists. The Commission may perhaps think that I am rather harping upon the subject of thermometers, but I believe that the accuracy of thermometers is a matter of great importance to physiologists and at the intermediate points. The great physiological point in the thermometer I think is about 98 degrees.

10,434. What is your opinion as to the need of a museum of scientific instruments, and apparatus, and machines, and tools used in the arts?—I think that that is a very important branch of the subject indeed. I need scarcely allude to the great importance that is attached to that on the continent. The name of the Conservatoire des Arts et Métiers will suggest it at once, which is the very best evidence indeed that I could produce. I have often visited it with great interest and profit. Moreover, I believe there are several others in Paris, some of more recent establishment, of the same kind; I look upon that as a most necessary part of any scientific system. No scientific system can be complete without examples of the apparatus that are being used in all branches of science, both in England and abroad, and on that point I speak from experience of the great use that such a museum would be. I am nominally the inspector of scientific instruments for India, but I am really the inventor of scientific instruments for India; that is my real function. I accept no instrument from a maker. I may say that no instrument that I send out is such as a private customer can obtain from a maker. For my own part I do not rate the instrument makers in England very highly. For their own purposes they are all-sufficient. They are tradesmen, and their purpose is to make fortunes, and not to advance science, except so far as in doing so they may make fortunes, and I have had to pass in review almost every description of apparatus that would be likely to be required for Government purposes, surveys, meteorology, and matters of that kind, and I have had to re-design every one of them. There is no instrument that passes through my hands that does not bear my mark in some way or other, and I have felt very acutely the want of great collections suggestive of ideas in the forms of instruments, because my establishment is a routine establishment, is part of the Store Department, and it is a Department of issue

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

officially. It has not become what I think it should be, somewhat of an experimental institution. Supposing that I think of some modification of an instrument which I imagine would be advantageous, I must adopt it almost without trial. I cannot go to the makers and say, "Now then, try if this will answer. Make one, "and try; and if it answers I will order so many," for the makers do not do that kind of thing; they are not fond of experiments. But, after considering the matter as well as I can, I have to come to a decision, and say, "That is the form which I think is best, "and we will adopt it, and, on my authority, you "will make the instrument in that manner." But if there were a great museum, such as I suggest, containing all the new developments in instruments and in machines and tools, to which I could resort, I should be able to introduce modifications with far greater confidence, and it would be an enormous assistance to me individually. I can speak of that as a matter of which I have felt the want very much indeed, so far for the assistance that it would render to a strictly Government office like mine, but when you come to consider its use to men of science, it would be enormous. I think I have noticed that, as a rule, men engaged in science are not good designers of apparatus. I can hardly say how that is, perhaps it is partly owing to their dependance upon instrument makers, and perhaps if they were left as much to their own resources as I was for 20 years in India, they would study an art with which I think very few persons are at all acquainted. I find very few persons who have really studied what I will venture to call the physiology of instruments and apparatus, and such persons would derive very great advantage, I think, from being able to go to an establishment where large collections of apparatus of different dates and the products of different minds were collected together in one view, some of which would contain some desideratum of which they were in search. I think, if they had such a collection to go to it would materially aid them in the choice of the apparatus that they required, and would tend enormously to advance exact experiments. The same considerations apply, of course, to machines and tools that are used in the arts. There is a profession which is more or less instructed in such matters, I mean the mechanical engineering profession; they are more advanced in their knowledge of the construction of machines, and in the use of them, in my opinion, than scientific men are in the construction, not in the principles, but in the mechanical construction of the apparatus that they use, and the advantage to the mechanical engineer would not be so very great, as I think it would be to the man of science, nor is there the same scope. Machines may be resolved into a very few principles. For instance, the principle of the turning lathe is a principle of such universal application that we find it simply in another form turned up on end in the drilling machine, and we find it in another form in the planing machine. The planing machine simply planes a straight line instead of planing a circular line, but it is essentially the same thing, and there is not the same variety of principle in machines and tools that there is in scientific apparatus, but still it would be more complete to have machines and tools represented, and particularly if the machines and tools of foreign countries were represented, because, although we pique ourselves upon our superiority in the manufacture of machines and tools, that superiority is passing from us. There is no doubt that some years ago there was no nation that could compete at all with England in such matters, but we have taught the rest of the world, and the pupil has now become somewhat in advance, in many directions, of his master. Also the spread of scientific education on the continent has tended to the application of more sound principles of construction in such things than with us, for the education of engineers in England, I do not hesitate to say, is excessively faulty, and the faultiness of that education has been the basis on which the India Civil and Engineering College has been founded. I heard the Duke of Argyll, in his address on the opening of that college, state broadly, in the presence of some of the leading engineers of the day, that the engineering profession was not sufficiently well educated for his purposes. Therefore, we have now what we had not some years ago, we have a good deal to learn from continental mechanics, and that is the reason why we should take to heart, and the sooner the better, that really they are applying to the construction of such things, principles that are a little beyond us, and therefore on those grounds machines and tools should, I think, be represented in such an establishment. At present we have nothing whatever of the kind.

10,435. An establishment of such a kind to be at all complete must be on a very great scale, must it not?—It must.

10,436. Would it not cover a good many acres?—It would be a large establishment, there would be no denying that at all.

10,437. Would you consider an establishment on the same scale as that of the Conservatoire of Paris would quite answer the objects which you have in view?—Yes; I think it need not be larger than that to begin with, but such an establishment, on whatever scale it was originally founded, is indispensable. It does not follow that it should be at once established on an extreme scale. I think that is a point for after consideration, but that the nucleus of such a thing should exist in England I have not the slightest doubt in the world.

10,438. (*Professor Smith.*) You do not think that there is any such collection in London at present that is of the slightest use?—There is none that I know of. There are scientific instruments at the South Kensington Museum, but they do not approach what I allude to; for instance, I may say, without egotism, that they have not got my theodolite.

10,439. (*Chairman.*) Was that Museum established with the view of including these objects?—I suppose so.

10,440. But you think that it accomplishes the objects very imperfectly?—Not at all, it is quite a nominal thing.

10,441. Will you be so good as to enumerate the institutions which you think should be under the State?—(1,) an observatory for physics of astronomy; (2,) an observatory for terrestrial physics, namely, meteorology, magnetism, &c.; (3,) a physical laboratory; (4,) an extension of the standard office; (5,) a metallurgical laboratory; (6,) a chemical laboratory; (7,) an extension of collections of natural history, and an able staff of naturalists; (8,) a physiological laboratory; (9,) a museum of machines, scientific instruments, &c. I believe that under one or other of these and existing institutions every requisite investigation will range itself. I have not stopped to inquire whether one or another is more or less important. My aim in the spirit of my postulate No. 2 has been *completeness*. It may be necessary for a manufacturer to prosecute only such particular investigations as promise direct and speedy profit. A great nation must not act in that commercial spirit. All the operations of nature are so intimately interwoven, that it is impossible to say beforehand that a given line of research apparently unproductive may not throw light in unsuspected directions, and so lead to untold and undreamt of treasures. A civilized people should believe that all knowledge of nature is valuable, and act on that belief. Nor have I attempted to group the various institutions enumerated. It is premature to do this. Many of them should for convenience be locally in juxtaposition, as for instance the two observatories (1) and (2) which certainly ought not to be far apart. The various laboratories should also be near each other. The probability is that any future developments of science, at present unforeseen, will admit of being referred to one or other of these institutions. At present there are many needed inquiries for which no home exists. The instruction of travellers in methods of observing is an important desideratum which some one of these institutions might readily supply. The "hints to travellers" lately issued by the Royal

Lieut.-Col.
A. Strange,
F.R.S.

24 April 1872.

Geographical Society shows how valuable such an arrangement would be. As I said before the lectures which should be given at those institutions should be, I think, mainly directed to inform the public, particularly the scientific portion of the public, of what was being done in the several institutions, and that they should not be elementary lectures of instruction. I think they would tend to keep up an interest in such institutions which it is highly desirable should exist. I do not want to see close institutions which the public know nothing about.

10,442. Have you any general remarks to make respecting those institutions?—I should like to add, that objection has been taken to some of my former observations made in public on this point without, I think, a full comprehension of what I meant—that you cannot teach people to be experimenters. That comes under the same category as the remark that you cannot order people to discover, nor can you. But when you find a man who has made considerable attainments in science, and has a considerable taste for it, when you find him ready to go on with his work, you may be able to teach him those practical methods of working in a great institution which he had not an opportunity of acquiring perhaps at the University, and in that way you might perfect his knowledge; but that is quite a distinct thing from creating investigators. I do not propose to do that by any process whatever. But if any such system as this can be adopted, that is to say, if there were any large group of public institutions for scientific purposes conducted by the State, the necessity would arise for such a staff of trained attendants and operators of different kinds, and that is the mode in which I propose to supply the want.

10,443. Have you formed any opinions with which you could favour the Commission on the subject of scientific societies?—The scientific societies of England form such a very conspicuous and important element in the world of scientific activity, that we can boast of, that I could not well omit it in a scheme which had any pretensions to completeness. Of course a scientific society is a private body and therefore it might be held that it had nothing to do with a scheme which, so far as we have gone at present, is strictly a scheme for State agency; but it is a fact, and we must not ignore facts, that the State does assist scientific societies already. Therefore I have not to contend for a principle, because the principle is established that it is fitting that the nation should assist certain bodies organised by private individuals and maintained by private funds for particular purposes. That principle is affirmed and is actually acted upon, I have not therefore to contend for it; but what I have to do is to show that the principle is only partially and inconsistently, and I think therefore not quite intelligently, applied. I have been engaged for the last two years from time to time as a member of a committee which was formed at the instance of the Statistical Society for the purpose of inquiring (and the inquiry is quite of a general nature) what could be done to enable societies already in existence to house themselves more economically and more conveniently than they are at present housed, and I may say what is very well known to every gentleman present, that a great many scientific societies are very badly housed indeed. They are some of them in borrowed rooms, some in hired rooms, rooms ill lighted, wanting in space and wanting in every convenience, and, in fact, very miserable domiciles, whereas other societies have the most ample and splendid accommodation, or if they have it not at this moment it is being provided for them. I believe there are five or six societies housed in Burlington House, namely, the Royal Society, the Royal Astronomical, the Linnean, the Chemical, the Geological, the Society of Antiquaries, and the Microscopic has been talked of, but I believe it is not settled, and it is a question for consideration. I do not say that it is a thing that you can possibly assert, but it is a question for consideration whether there are not other societies whose utility to the nation is not sufficient to give them as great a claim, if there is any claim at all, to the help of Government in this way as those five or six societies. I wish again to guard myself against being supposed to be a grievance monger. I am a member of two of the favoured societies, the Royal and the Astronomical. I take more interest in those two societies than in all the others put together. I do not put them forward as two societies which I am interested in, and which are more comfortably housed than others, but merely as part of the system of science in the country. And it appears to me that there should be some principle observed in the selection of the societies for aid of this kind. I am at present aware of no principle whatever, nor does there exist any body whose distinct duty it is to consider this question; this points always in the same direction, that there is really no body in particular and no minister in particular who is competent to take up a question of this sort, and therefore I imagine—I do not know it as a matter of fact—but I can only imagine that the societies which have obtained those privileges have done so by means of individual influence and pushing, and so on, which is always open to those who want anything in this country. It seems to be the way in which most wishes are gratified, not so much by appealing to a systematic source which can gratify their desires but by the exertion of personal pressure. I believe that in that way most of those societies have obtained their present concessions, and I think that that should not be so. I think that the question as a whole should be considered, first, should the Government assist private bodies at all? That question is answered and I need not discuss it. It does assist them, and therefore I conclude that it considers that it should. And then the next question is, what bodies should it help, and what should it leave unhelped? That is a question which apparently there is now nobody to answer, and therefore it is a question which I would most humbly and respectfully submit to this Commission as one entering into the whole question of the advancement of science, and because there is no doubt whatever in my mind that we owe more to our scientific societies than to any agency in the country for the condition to which science has attained, such as it is in England; and therefore they have a distinct claim, I think, to be thought of, at any rate. But then would come a question similar to several that have proceeded from your Grace. Would not this be a very large building if it were to contain all the societies? There is no question that it would, and of course that is an administrative question also. Assuming that it were considered the duty of the State to assist more societies with house room, it would then become a question whether you would have them all under one roof or whether you would not. There are several answers to that. Of course I am speaking more of principles now than of actual arrangements. I think that there would be great benefit in congregating them as much as possible, and in conferring upon the building containing them more of the character of a club than at present appertains to it. I do not mean a club in its dining and billiard-playing aspects at all; but I mean this, that it would be very advantageous, I think, if such a building were always open up to a certain time in the night throughout the year, and that there should be a certain community of rights in certain parts of the building. For instance, if the libraries could be congregated together, that would be one thing; and if also there were a public central hall, which all the societies could frequent and could converse in, and make appointments in, and so on, with, of course, some arrangements for light refreshments. I think that dining tables and things of that sort are not necessary, but that we should be able to get a cup of tea whenever we want it. Of course the expenses appertaining to those arrangements would rightly devolve upon the societies; but the building I think should be such as to admit of such arrangements. I know it is sometimes said that the advantages expected from the congregation of societies in one building have not been in practice obtained to their full extent, that there is not

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

that intercommunication which formed one of the grounds on which the societies were housed together. But I think it is in a great measure owing to the want of a central place of meeting. It will be in the recollection of several members of the Commission that some time ago the little light refreshments after the meetings of the Royal and the Chemical Societies were made use of by both societies. I believe they are not now, but I used to consider that one of the most agreeable and profitable parts of the evening. I believe there were difficulties about it, and it has been temporarily discontinued; but whilst it existed I thought it an exceedingly useful and agreeable thing.

10,444. (*Dr. Sharpey.*) Are you not aware that care was taken in the planning of the new building that what is called the ante-room, adjoining the meeting room, of the Royal Society should be made very spacious, in order to allow of the assembling of members of different societies, who might meet on the same evening, for conversation and refreshment?—I was not aware of that, but I am very glad to hear it; it is precisely that which fulfils what I allude to, and that is the principle which I think should be observed with regard to all the societies. Of course it becomes a very difficult question. The building having been erected and a certain number of societies housed in it, the proposal to turn them out and to appropriate the building to some other purposes would be resisted with an amount of energy which I think nothing would overcome.

10,445. You are aware, are you not, that there would not be room in the new building for all the societies desiring accommodation?—That is the practical point, but there remains the other question, that there are a large number of societies, I think about 15 or 20, which at present are thrown entirely on their own resources, and it curiously happens that those who have the smallest resources have the smallest aid, as a general rule, though not perhaps strictly speaking so. I should like to refer, in connexion with this point, to the case of the Royal United Service Institution, to show how extraordinarily these questions are sometimes dealt with. That institution had three months' notice to quit the other day from the Chancellor of the Exchequer. How it devolved upon him I am sure I do not know, but he gave it, and they were about to be turned out into the road, a huge museum, the greatest collection of military and naval objects, I believe, in the world, and large models, and a number of things collected at an enormous expense by private individuals on the faith of being allowed, at any rate, to have good warning before being obliged to leave the building, but they got notice to quit in three months. That was a measure so obviously incapable of being carried out that it was rescinded, and they have now a longer tenure, but still an uncertain one. That matter resulted in a deputation to the Chancellor of the Exchequer, from whom was elicited an assurance that their case would be taken into consideration by the Government. I forget the exact terms of it, but it was to the effect that their claim was recognised to certain aid from the Government, and would be considered, and the same answer was given to a deputation, of which I was a member, with reference to all those houseless societies. We waited upon the Chancellor of the Exchequer and were received with his usual courtesy, and we received the assurance that the matter would be considered, and that it was one which we had a right to press upon the Government. In our committee there were one or two modes suggested of meeting this difficulty, one was that we should merely ask the Government for the site on which we should erect a building, and a company should be formed, I think, with shares to pay for the erection of the building, and that a rent should be charged, and that the whole should be so arranged as to pay the shareholders five per cent. It was a joint stock jobbing sort of proposal which I did not assent to at all. I did not think that it was the right way of doing it, and I should be satisfied now with having called the attention of the Royal Commission to the subject as one which I think forms a portion of the inquiry that they are engaged in.

10,446. (*Chairman.*) Do you consider that each society necessarily requires separate apartments; could not the same apartments be used, to some extent, by different societies?—No; they would require certainly private apartments to a very limited extent, that is to say, their office would require to be that of the society itself, without interference on the part of the other societies, but the library need not at all necessarily be a distinct apartment. I think there might be one general central library, in which the books of the various societies might be collected, and also the theatre, the place of meeting, could be used by several societies, because they need not all meet on the same night, and in that way all the societies would have the use of a far superior theatre to that which they could have if each had a separate one, and therefore it would be economical to them, and the attendance also would be less if there were a community of apartments in that way.

10,447. Have any arrangements of that kind been attempted with regard to any of the societies?—Yes; I think it exists, or it did exist, I know, for some time at Burlington House, by a sort of private arrangement. The Geographical Society used to meet in the Royal Society's rooms.

10,448. Do you know whether any practical difficulties were found to arise?—I never heard of any. I rather think that some of the societies now in Burlington House meet in the same room.

10,449. (*Professor Smith.*) The Mathematical Society used to meet in the rooms of the Chemical Society, used they not?—Yes; but the instance I have just quoted is an important one, because the Geographical Society was a very large society indeed, and a very crowded meeting, and they used always to meet in the Royal Society's room, which has now been pulled down, as you are aware.

10,450. (*Dr. Sharpey.*) The Geographical Society receive 500*l.* a year from the Government, and they have from their own funds purchased a house in Saville Row and adapted it for their offices, and for the exhibition of their maps, but for the last two years they have been indebted to the University of London for the use of a hall for meeting in, because they are a very large society, and have very large meetings; therefore it is very difficult to get a room that will hold them?—Yes, that is the case.

10,451. Looking to the societies now in Burlington House, do you think that it would be an economy if some of them met in a common meeting room?—Yes.

10,452. That would apply to those who do not meet so often as once a week, they could meet in different weeks?—Of course the days would have to be arranged.

10,453. It was proposed originally by the Office of Works of that time to have only one common meeting room for all the societies in Burlington House; but it was pointed out that one object of the societies being under the same roof was that they might meet, at any rate several of them, on the same evening, and it would be impracticable to do that if they had but one common meeting room, and the consequence is that there have been separate meeting rooms provided for several societies; still probably some of those meeting rooms might accommodate two or three who meet on different nights, and you think that that would economise space and also the expense of fitting up those meeting rooms?—Yes, it would economise space, and not only that, there is a higher advantage still in it, that if you have a smaller number of meeting rooms they would be more commodious.

10,454. You state that there seems to be no intelligible principle as to the selection of some societies and the leaving out of others; in the first place, it is necessary as regards the particular locality of Burlington House that there should be a selection because you cannot introduce all?—Certainly.

10,455. Then does it not occur to you that there might be a principle of seniority; are you aware that

Lieut.-Col. A. Strange, F.R.S.

24 April 1872.

originally the Royal Society had its own apartments in the city ?—Yes.

10,456. And that very nearly a century ago, when Somerset House was being built, George the Third assigned to the Royal Society and the Society of Antiquaries apartments there, to be held during the pleasure of the Crown ?—Yes.

10,457. Provided always that they were to be applied to no other purpose ?—Yes, I am aware of that.

10,458. And are you aware that Sir William Chambers was directed to furnish plans and descriptions of those apartments which you know the Royal Society possessed ; but when they moved from Somerset House it was stipulated with the Government that their removal should not in any way weaken their claim upon the Government for accommodation in some other place ?—Yes.

10,459. So that those two societies stand in a particular relation to the Government with reference to that claim ?—No doubt that is so.

10,460. Several other societies had been also located in Somerset House, and when their apartments were required for another purpose it was determined they should be transferred, was it not, to Burlington House ?—Yes.

10,461. Do you not think that that might afford an explanation of why some are to be accommodated there and others not ?—It is possible.

10,462. Do you think that all self-constituted societies are of like importance and would be entitled to the same aid ?—Certainly not necessarily so. That would involve an examination into their respective claims which there is nobody to make, and that is the difficulty.

10,463. Seeing that it would be impracticable to introduce any more societies into Burlington House, would you propose that there should be another large building erected for the purpose of accommodating those societies ?—I do not see any other solution, supposing their claims to be admitted.

10,464. You would prefer that to giving them the means of providing themselves separately ?—Yes, that would be far preferable I think. I might say with reference to what has just been pointed out to me as to the mode in which the Royal Society gained its footing, that in those days the number of scientific societies was very small, in fact the Royal Society was the scientific society and represented science ; but gradually the numbers have increased, and claims have been put in by degrees without any proper system I think.

10,465. Perhaps you are not aware that the Royal Society gave something in the shape of an equivalent, they gave to the nation a collection of objects of interest ?—Yes ; the Geographical Society which you mentioned as receiving a grant of 500*l.* a year receives it on condition not only of keeping up the apartment but of throwing the maps open to the public, and any member of the community, although not a fellow of the Geographical Society, has an absolute right to inspect these maps.

10,466. (*Professor Smith.*) Are you aware of a special difficulty in the way of young societies, I mean that it is almost impossible for them to obtain a charter ?—I am connected with one very young society which has been in existence only a very few years, namely, the Meteorological Society, and we got a charter of incorporation about four or five years ago.

10,467. Is not that the last which succeeded in doing so ?—I am not aware—that difficulty has not come to my notice. I only know that we got our charter.

10,468. The Mathematical Society has been trying ever since its existence to obtain a charter, but has not succeeded ; are you aware of that ?—No. That might constitute a principle of selection ; but if there is to be a difficulty about getting a qualification, that would not be quite a fair one.

10,469. (*Professor Huxley.*) Has it occurred to you that the Royal Society, not only on account of its seniority, but on some other grounds, has a right to be considered in an entirely different light from all the rest. You are doubtless quite aware that in any other scientific society the only condition of membership is that a man pays his entrance fee and his subscription, whereas, as you are aware, the election to a fellowship of the Royal Society is upon a totally different foundation ?—Quite so.

10,470. Does not that put the Royal Society quite apart from its seniority of standing ?—I think it does. I think if the Royal Society alone were provided by the Government with house room, the argument would be sustainable in that direction, that it is exceptional ; there is no doubt in the world about that ; but then many other societies which are not exceptional have gained the same advantages as the Royal Society.

10,471. Still you yourself, I take it, would not put the Royal Society upon the same footing as other societies ?—No ; it is notoriously on a different footing.

10,472. Does not that lead further to the consideration whether it is at all practicable or desirable to throw the library of the Royal Society with that of the other societies into a common library ; would that be just to the fellows of the Royal Society ?—It is quite a fair question to raise, I think, and at the moment I should hardly like to give an answer to it.

10,473. Take the lowest pecuniary view of the question. A fellow of the Royal Society, as you are aware, pays 4*l.* a year as his subscription, and there is hardly any other society in which the subscription is more than 2*l.*, and on the basis of pecuniary foundation is it not rather hard to make them share their privileges with those who pay so much less ?—I should not like any comparison made. I think it would be a matter for mutual arrangements.

10,474. Do you think it a fair thing to ask of the fellows of the Royal Society ?—I am as jealous of the privileges of the Royal Society as any member of it; and if it stood alone in the matter I think I should hardly have brought it forward.

10,475. I did not apprehend quite clearly what answer you gave to the suggestion of Dr. Sharpey as to how you are to find out which of the societies calling themselves scientific are entitled to the privilege of government lodging ?—That is precisely one of those questions which I remarked there is nobody to answer at present.

10,476. And anybody who had to answer it would find himself in rather a hornet's nest, would he not ? —If this Commission were a standing commission, I should say at once, refer it to the standing commission ; but there is nobody to answer such a question now.

The witness withdrew.

Adjourned to Friday next, at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 26th April 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
BERNHARD SAMUELSON, ESQ., M.P.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

GEORGE B. AIRY, Esq., C.B., P.R.S., examined.

G. B. Airy, Esq., C.B., P.R.S.

26 April 1872.

10,477. (*Chairman.*) You have been Astronomer Royal for a great many years, have you not?—I have been Astronomer Royal for 36 years.

10,478. And at present you are also President of the Royal Society?—Yes.

10,479. The advancement of science is a subject to which you have paid no doubt much attention?—In various ways. Ever since I was at Cambridge, in fact, it has been before me in some way.

10,480–1. Have you any measures to suggest which you think it desirable should be adopted with a view to the advancement of science?—Mr. Lockyer has just placed before me the précis of the remarks by Colonel Strange, and there are some things in it which I think are well deserving of attention. One of the first that occurs is on page 2, where he says that there should be at least one public observatory in England for researches in the physics of astronomy. It is quite true that there is scarcely any provision for that subject at this time; the fact is, it has grown up a great deal in modern times, and the field of astronomy is far wider now than it was. When I began to be an astronomer, such questions as those of the constitution of the sun and the like were not entertained. They could not be followed out, because the instruments were wanting; but, especially since the duty was taken off glass (I think that has been the critical point in astronomical physics), the improvement in instruments of various kinds has been so great that it has led up not only to improve the old observations, but to speculate on new ones to a very great extent.

10,482. Do you think it would be practicable to adopt any measures at the present observatory at Greenwich to make observations of that character?—I think it is possible that it might be done, but I am not prepared with a plan at present, and I am very much inclined to think that the difficulties in these matters will be rather in detail than anything else. There is always a difficulty in keeping an observatory of rather an indefinite character in such a state that it will satisfy the public demands. One man will go into the matter so extremely fancifully that he will be laughed at, and another man will do nothing at all; and it is very difficult indeed to satisfy the public upon the efficiency of such an observatory.

10,483. I think Colonel Strange expressed an opinion that space would be an obstacle at Greenwich to undertaking any observations of that kind?—That would be so in its present conditions, but that might be overcome by degrees, I have no doubt. It has been found necessary within the last three or four years to extend our grounds at Greenwich. I represented in the first place to the First Commissioner of Her Majesty's Works that we wanted space, and that I proposed to apply through the Admiralty, which is my proper department, for more space. The First Commissioner of Works received my notice very courteously, and I then went on with my application in a formal way, and in no long time a piece of ground was allotted to me. I ought to say that it requires the Sovereign's assent under the royal sign manual. But judging from what occurred in our case, I do not think that there would be any difficulty in further extension; not, perhaps, in juxtaposition with the present ground, not (as an estate owner would say) in a ring fence; but I think a piece of ground might be got from another part of the park, where the public would not miss it very much, and where it would be in sufficient proximity to the Royal Observatory to be under the same general control.

10,484. If a department of that kind were instituted, do you see any objection to its being placed under the Astronomer Royal, or would it give him too much to do?—It would give him much to do, but still he would not have so much to do as the First Lord of the Admiralty. A great deal may be effected by organisation, especially with the license to have officers of good position under him; to have lieutenants of a good class. In the old state of things at the Greenwich Observatory it would have been impossible to do anything of that sort, because the officers whom I found at the Observatory, when I first went to it, were of a kind totally incompetent to anything of the sort; and the first stipulation that I made upon going to Greenwich was that I should have for chief assistant a man of good position from the University of Cambridge—a high wrangler from the University. That was sanctioned, and I have now had three chief assistants in succession, all men in that position. My present chief assistant, Mr. Christie, is a fellow of Trinity College at this time, and was, I think, fourth wrangler, or a high wrangler, at all events, and he is a man who is likely, I think, very highly to support the credit of the observatory; and I could trust almost entirely the interests of one observatory to a man of that class with a moderate supervision from myself, and to another such man I could entirely trust the interests of another observatory, with similar supervision from myself. Whatever is done in a place like this, responsibility must be concentrated upon the one man who commands all. I should not contemplate any diminution of that responsibility, but I do not think there would be any difficulty in carrying out an extension of that kind.

10,485. Are you prepared to express an opinion as to whether it is an object which would be a proper one for the Government to take up as a State establishment?—The Government are already pushed very hard in their estimates. The screw is always put upon them, "Cannot you reduce the estimates a little more?" And then it would always come to a question of extensive feeling in the House of Commons, and of popular feeling out of the House of Commons; and I am confident from what I have seen, that those two bodies would not in every case support an extension. The House of Commons would be more likely, I think, to do so than people outside. I stated the other day, in Colonel Strange's hearing, that when I mentioned to a most respected friend of mine, a man in the country, upon whose judgment I should have relied more than on that of any other person that I know, something of the experiments in the Harton colliery which I undertook; and in mentioning the thing to him, I said that the charges were entirely my own, except that the Admiralty assisted me with a grant; he said, "Of how much?"—"100*l.*," I said. "Then," he said, "I solemnly protest against every portion of that 100*l.* which I shall have to pay." I think it will be found that there is a greater extent of that feeling in the country than the advocates of science frequently reckon upon.

10,486. Should you say that it is an object which is not very likely to be prosecuted with sufficient vigour unless taken up by the Government?—I do not see how it could go on except it were taken up by

G. B. Airy, Esq., C.B., P.R.S.

26 April 1872.

the Government. I do not believe that it could go on in any other way.

10,487. It is not likely, you think, to be prosecuted by private individuals, or by other public bodies such as the Universities?—No, I think that their funds are almost all required for other objects, and the difficulty even of getting the business into shape is extremely great. Great difficulty, as your Grace is aware, has been found in creating anything like a public fund in the Universities, even for purposes which were more germane to their ordinary pursuits than these. I think nothing but the Government could do it.

10,488. Then such observations as Colonel Strange thinks desirable, in all probability, will either not be made at all or must be taken up by the Government?—That is my view, and when we come to the distribution of money for the expenses in those matters you will find a very great difference of opinion. On the second page of Colonel Strange's précis there is a quotation from Mr. Chambers, who, when speaking of the Royal Observatory, says: "An enormous sum of money is annually misspent in printing with excessive detail observations which nobody reads and cares for," and so on. From the time when I was first appointed to the Observatory at Cambridge, and subsequently at Greenwich, I have expressed the same thing myself to some extent, that is to say, I have repeatedly brought before the Board of Visitors the question whether we might not omit the printing of a great quantity of original observations; and at one time, at their request, I took the opinion of several persons whose decision might be supposed to have some weight. I don't remember who they all were, but I remember one was M. Biot of Paris, and I remember another person whose opinion was expressed with equal energy with M. Biot, was the late Professor Johnson of Oxford, and they both most energetically urged that the printing ought to be kept up in the present shape. I think it was their opinions, in a great measure, that induced the Board of Visitors of the Royal Observatory to recommend that the printing should be kept up in the same state as at present. But it would be a great thing if we could avoid it, not simply for the expense of the typographical work, but for the labour and expense in the preparation in the Observatory. The amount of time spent in reading proof sheets and the like is very large indeed, and amounts to considerable expense in the provision at the Observatory.

10,489 Then you would be disposed to agree with Mr. Chambers?—I should personally; at least I should have been some time ago, and indeed I should now, but the demands especially from foreigners are always, Cannot you print such and such a thing in a greater extent, and make every step complete, at any rate, in the exhibition of them? That has occurred in several instances. And even from persons in England I have had some very strong representations of the same kind, of their want of meteorological observations in greater detail, and my answer has been, "Very few persons want them, but whenever you want anything we will copy it in manuscript in any detail you please." Sometimes applications have been made in the spirit of that answer, and sometime not. Perhaps I may be allowed to remark with reference to what Colonel Strange has said, that the Exchequer Standards Office is hardly supervised by a Royal Commission. There is a dormant Commission, but the office is really under the direction of the Warden of the Standards, which is a far better arrangement. The Commission have made their report, and have then disappeared in the usual way.

10,490. Are meteorological and magnetic observations carried on at Greenwich?—Yes, they are carried on with a great deal of accuracy.

10,491. Colonel Strange expressed an opinion that it would be desirable to have a separate observatory for those observations, do you agree with him in that?—I do not think I should at all. I should express this as my opinion, that when anything admits of being brought into a continuous routine we can carry it on to any extent.

10,492. You do not find that it interferes with your other work?—By no means to such a degree as to be troublesome. Some physical observations to which Colonel Strange has, I think, attached some importance, such as continued observations of the spots on the sun, could be carried on very well at Greenwich, because they are things which would occur every day. The things which would trouble us, and would trouble almost any other office, I believe, in the same way, are those things for which no precise rule of continuation can be given. In the earlier paragraph on page 2 of Colonel Strange's paper, he says, "At least one public observatory for such purposes is required in England. It should be organised to study photographically, spectroscopically, and ocularly, the structure of the sun, and the changes therein, the physical structure of the moon, planets, comets, asteroids, &c., so as to furnish *data* for studying the relation to each other and to the earth of the various heavenly bodies. It should execute a map of the moon," and so on. With regard to that, I may say that much of that could be done under the general superintendence of the Astronomer Royal. He would have a good deal of work on his hands, of course, and perhaps it might be done a little better if it were made an independent office; but still it is a series of observations which admit of being organised in routine, and which could be carried out advantageously by a Government establishment. When they cease to be of the order of routine, I think that a Government establishment fails. Colonel Strange also says, and I think it is a faithful representation, "The Standards Commission does not profess abstract investigation, or only to a partial extent. Its researches are mainly for its own purposes only, viz., for ascertaining and maintaining the values of its various standards of measure, weight, and capacity. And these, no doubt, it will still have to continue, though many of them will be repeated by the physical laboratory (if established) and the Ordnance Survey. The Standards Department is at present not available to the public, but only to public institutions." That, I believe, is so; it is not quite sufficiently accessible to the public; but still the Standards Department in the way mentioned by Colonel Strange is one of those bodies undertaking a routine duty, and which, as I stated, can, I think, be well worked under the Government, and must be worked under the Government. I think that it might very possibly fail if it attempted to grasp any other subjects. I may perhaps remark that, looking to the general spirit of Colonel Strange's paper, there is, in my judgment, too much of an idea that commissions could be appointed which would do everything which is wanted whenever it may occur. I do not think that that is possible. I think that as soon as anything is found which is in such a state of doubt that it requires more accurate and more extensive investigations, the onus of carrying them on must, generally speaking, fall upon the officers who have discovered the want of them. On page 6 Colonel Strange says, "About 10 years ago I was intrusted by the Secretary of State for India with the designing of an extensive series of geodesical instruments of the highest class for the use of the Great Trigonometrical Survey of India. The alloy aluminium bronze attracted my notice as probably suitable for some of my purposes; but I could obtain no reliable data as to some of its properties, such as tenacity, rigidity, co-efficient of expansion, &c.; nor did any institution exist whose services I could claim to solve my difficulties." It is a thing for which no want of the same kind had ever been experienced before; and with regard to the special alloy it was a new one, and it was impossible to determine these points which Colonel Strange wished determined. But I imagine that for all the needs for investigation to which allusion is made by Colonel Strange, it is impossible to make provision beforehand by the institution of commissions or bodies of any kind, and they

G. B. Airy, Esq., C.B., P.R.S.

26 April 1872.

must generally be worked out by persons who feel the want.

10,493. You do not think it desirable that any permanent government establishments should be founded with a view to take up questions of that kind ?—I do not, and for this reason, that I feel myself that I could not plan an establishment which would do it. If a distinct plan were brought forward for consideration, I might be better able to pronounce a trustworthy opinion, but at present I do not see how any establishment is to be planned for the purpose.

10,494. Do you think that when wants of that kind present themselves, it is desirable that the Government should give assistance ?—Yes. The assistance which the Government can give will be mainly in money, but I think it very desirable that the Government should entertain benevolent intentions, without saying precisely how they are to be carried out. But my own belief is that it must generally be done in money. On page 7, Colonel Strange says with respect to Museums of Scientific Instruments and the like, " At present the designing of scientific apparatus of " the higher order is in the hands of a few makers " whose views of possible perfection must be influenced " by trade considerations. As a rule men of science " in England are not sufficiently conversant with the " intimate structure of the apparatus they use, nor " are they well informed as to what already exists ;" and so on. I should say with regard to this, and especially I know it with regard to such things as telescopes, that if you wish to have any improvement in the parts of a telescope, we will say in the eye-piece, it is of no use to go to a maker; he cannot improve it; his mathematical education has not been sufficient for it. I have been quite struck by seeing that even in some of the commonest instruments, the makers of them are not at all aware of the condition which is necessary for the action of the instrument, and they must learn those conditions from persons who have had a more regular scientific education. I once represented that to an optician of some repute who sold stereoscopes. I said to him, " This stereoscope is quite useless to me and to many " other persons." The maker did not see why it should be so, and he inquired of me why, and I said, " Because, if you look at it, it is quite clear that the " lenses are in such a position that the two eyes can" not see through the two lenses at once, which is an " essential condition of the stereoscope." The man was not aware of that at all ; he was a man conducting a large business, and in high repute, but he was not aware that that was an essential condition of the stereoscope ; and of course it will be understood as more likely still that there should be difficulties of that sort in the thing which I have just mentioned, the improvement of the eye-pieces of telescopes. I say that all improvements of that kind must come from persons of a higher class of education, and that such improvements will not be suggested by a museum of scientific instruments and apparatus and the like, for I found an optician who was selling those stereoscopes off, it may be, by hundreds, and yet he would never have found out the cause of the defect.

10,495. (*Professor Huxley.*) Might not a museum of instruments be of advantage to persons of higher education ?—Very possibly, but the thing at which we really want to begin is the practical matter of physics —mathematical education—that is the point to begin with.

10,496. (*Chairman.*) That is a point upon which the Commission would like to have your views, as to whether anything more is required than is done at present in this country ?—Your Grace knows the constitution of the University of Cambridge as well as I do, and you know its excellencies and in some measure its defects, and I have no hesitation in saying that I look to the University of Cambridge as the source from which general improvements in the scientific education of persons of all ranks may be expected to flow best. Its system in respect of the subjects which really are taken up there is admirable; but it requires some modification. The subjects which occupy some of the best men at Cambridge are what has been truly called *eidola specûs.* They are far too much confined to pure mathematics or to imaginary problems of mechanics, &c., things which are bred in their own minds, but have no bearing on natural philosophy. A Cambridge man sits in his room all the evening and thinks of them, and produces matters of great ability and great ingenuity, but they are not of any use for the science of the world. I have tried very hard myself, and even within the last few years, to do what can be done at Cambridge in the way of making some alteration, and I have found a general desire to assist me upon the part of the authorities ; but everything will depend upon the personal character of the examiners for honours there. One considerable fault is that the examiners for honours are taken too much from the University, and too much from the younger men of the University, who have had no acquaintance with the current science of the world ; and the best thing that could happen to the University would be to have a good deal of foreign blood in it. That has been felt in the medical examinations, and at the present time the medical degrees at Cambridge are tested through medical examiners from London and Edinburgh.

10,497. Then your suggestion in that respect would be chiefly with regard to the higher examinations ?—Yes.

10,498. But in the more elementary examinations you do not think that any change is required ?—No ; and even up to a high point there can be nothing better. In many points the Cambridge examination is admirable.

10,499. Are any changes contemplated at present with reference to the character of the higher examinations ?—I do not think that there are, but some prizes have been established in some of the Colleges in the nature of Fellowships, and in other places of scholarships, expressly intended for natural science, and I think in some measure for physics—mathematical science—but I am not quite sure of that. To show how matters of detail, with which it is difficult for an external body or commission to meddle, interfere, as I conceive, with the high interests of the scientific education of that University ; at the time when I took my degree there were different examinations for persons aspiring to different degrees of honour. I am not sure whether that was so when your Grace took your degree at Cambridge—whether there were different examinations for the men who were supposed to do differently in the Senate house—but in my time that was so. The same questions were not given to all the candidates, but they were divided into groups, and one group answered one set of questions and another group answered another set of questions, and so on. I suppose there was some inconvenience in that plan, or at any rate there was a good deal of trouble in the arrangement, and some time ago it was arranged that men going for honours should have the same questions all through. The effect of that is that men who are competent for the lower honours get many questions which it is impossible for them to answer, and that men going in for the high honours have their time occupied in a great measure by a number of questions which ought never to come before them, because they are presumed by all the education that follows ; and in consequence of that it has been found necessary to lower the standard for the purpose of accommodating the questions to all classes ; the standards of the questions have been lowered. I was very indignant indeed when I heard of one thing which I particularly mentioned in a printed paper once to the University of Cambridge ; namely, that one subject of which the results are known to every officer engaged on the geodesic survey or the like, the theory of the figure of the earth supposed heterogeneous, was expressly and by name detached from the studies of the University. I looked at that as a dishonour to the University ; and I mention it now as one of the consequences of a system with which it is very difficult for

G. B. Airy, Esq., C.B., P.R.S.

26 April 1872.

any external body to meddle at all, but which may produce very bad effects. I have spoken twice in public in the University of Cambridge on this matter, and once was on this occasion. I had been requested to give the Rede's lecture in the Senate House, a public lecture, which is exclusively upon a physical matter, but it is only a single lecture. I gave my lecture upon a subject which I thought proper for the time, and I then added to it a number of oral remarks upon the connexion which this institution had with the University in general, and how much it might promote physical science, and how great the defect of science was, and I pointed out particular instances. I was very much struck then to observe how sensitive the undergraduates were to those remarks. They cheered very heartily when I said that it would be possible to introduce such a thing as the theory of sound, and the theory of magnetism, and the theory of waves, into the studies of the University, all of them things which are well known out of the University, but are not in the least known in it. A good deal of correspondence followed, and at last I undertook gratuitously to give a course of lectures on magnetism in the University, and my lecture room was filled with undergraduates, who were most anxious to learn something about magnetism, and they took the greatest pains to learn, especially in this way. They actually divided themselves into copying classes, in order to copy all the manuscripts of the mathematical investigations which, in default of books, I had prepared for them on large cards which I had put up against the wall. The representative of one class was engaged in copying one paper, and the representative of another class was engaged in copying another, and so on, and they all ultimately got complete manuscript copies, and they were distributed accordingly in that way. That was the genuine feeling among the students there; but, as I have said, from the circumstance that the examiners are so much concentrated in their own rooms with the studies which present themselves to their own minds, those things never come into the examination, or scarcely at all; and that is the want now of such a place as the University, which I look upon as the most hopeful source for education; it must be in the choice of examiners that the movement must be made.

10,500. Have you ever made any suggestions at Cambridge as to the alteration of the system of selecting examiners?—I do not remember at this moment whether I have or not. I do not think that I have in public, but I have in private frequently.

10,501. What is your opinion, generally, as to the value of the professorial system of education?—In that case the responsibility comes more distinctly upon individual persons, and a great deal can be done by it, but not exclusively. If the professorial system be taken alone, it will generally be a very shallow system indeed. There is nothing to be compared to the tutorial system at Cambridge for working men thoroughly into the details of every subject which they are studying. The professorial system cannot do that at all, but it can convey a knowledge of a great many things, and apparatus can be exhibited and could be submitted to the handling of students, and so on, for which there is no provision and no possibility in the tutors' rooms.

10,502. Do you think that it would be desirable to establish any connexion between the professorial lecture and the tutorial instruction? Yes; and I think it would be possible to do that, and that it might be done with advantage.

10,503. When you say that you think a connexion between the teachers and the examiners very desirable, to what sort of connexion do you refer?—It is a question which has been somewhat debated. On the one hand Mr. Lowe has desired to have a normal establishment of examiners, who should examine throughout every educational establishment in England, and, on the other hand, it has been very much opposed by Dr. Playfair, and I take Dr. Playfair's side in it. I do not think that it will be easy to make an examination efficient except the persons speak the same language, and that can only be secured by their having worked in much the same manner, and, in fact, been connected in the system of the University.

10,504. The examiners, you think, should either have been or should be teachers?—Yes, they should at least have been taught in the system of the University.

10,505. Would it be desirable, in your opinion, that the examination for the mathematical tripos should be conducted in part by examiners not belonging to the University?—I think it would. There are many persons who have orignally been connected with the University, and have been separated from it, and who have had the experience of other societies and of other times, and they would be the best in my opinion. For instance, Sir William Thomson in matters of electricity and telegraphy. He is a Cambridge man, and he had the good drill of a Cambridge man, and he has subsequently had considerable experience in the world of external science; and a great many non-resident persons could be found who are well acquainted with the Cambridge system.

10,506. Have you any knowledge of the new triposes that have been established since your immediate connexion with the University ceased?—I have not much acquaintance with them. My belief is that they do not touch upon the subjects which are particularly contemplated at the present time.

10,507. Many of them embrace to a certain degree the same subjects that are taken up in the mathematical tripos, but they are not generally treated mathematically?—That is so.

10,508. Are you aware whether those examinations are conducted exclusively by Cambridge men?—Yes, they are, I believe.

10,509. Do you wish to make any remarks on the pecuniary position of scientific professors at Cambridge. I believe that in most cases there has been a good deal of advancement in that respect?—I believe so, but I am not acquainted with the details.

10,510. Would not any advice from you to the effect of the evidence which you have given be received with great respect at Cambridge, if it were brought specially before them?—It would be received with some respect, but still I am only one person: it might perhaps be received with as much respect as the opinions of several other persons, but after all we should be nothing in comparison with the number of persons there who have to judge.

10,511. Are you of opinion that anything can be done to encourage the habits of attending to natural philosophy as a matter of investigation?—If you could take the book out of a man's hands and put the telescope into it instead, or something in that way, it would be a step gained. I do not know that anything else can be done.

10,512. You do not think that any action could be taken by the Government in that direction?—No, I do not think it could. I have been in the habit of relying upon the Government for very little, except money, and generally speaking I think that is the principal way in which the Government can assist anything; but the Universities, which are our best places of education, without doubt do not absolutely want it; they are beyond the reach of Government influence.

10,513. The Government can scarcely be expected to advance money without good advice; how would you furnish them with such advice?—I think that little can be done, except when occasion arises. I think that the best thing would be for the Government to call specially upon persons in whom it has learnt to have some confidence, but for an opinion *pro re nata* and not as a matter of systematic provision.

10,514. You think that on any occasion the Government ought to endeavour to get the best advice in its power?—Yes.

10,515. Do you think that more should be done in the way of money advances from the Government than is done at present. I refer to the annual grant to the

Royal Society of 1,000*l.*, which is, perhaps, not quite for the purposes of which you have been speaking?—It is properly for the facilitation of the enterprises of individual experimenters, and that is the best that can be done at present, I think, in that way. For instance, I remember that at one meeting of the Government Grant Committee we had an application from Mr. Lockyer with reference to a telescope to be used for the spectroscopic examination of the sun, which was a very proper object, and which could then be very well considered, and for which when approved the means of supplying funds were simple. I think that in a case of that kind the apparatus of the Government Grant Committee of the Royal Society, supported by a grant annually made by the Government, is as good an arrangement as could be made. But I may state generally that I see great difficulty in promoting science by the agency of such a Commission as this, which I now address, or of any one body. I see great difficulty in making much progress in promoting science except where it admits of being reduced to detail. The Government Grant Committee is almost the only thing which it has been found practicable to apply to the promotion of science in any regular way, and I believe it works extremely well in that respect. I do not know that anything better could be done than to rely upon it. The selection of the members of the Government Grant Committee is made with great care by the body that may be supposed to know as much about these things as any other body in England. On various occasions the Royal Society and the Astronomical Society and other bodies have felt the want of assistance for special purposes, and they have applied specially to the Government, and I do not think that the assistance has been refused in any case that I know of. Sometimes it has been done by private persons, as, for example, by myself, in the instance to which I was alluding just now, namely, the experiments at Harton colliery, where the assistance of the Admiralty was cheerfully granted.

10,516. I understand that you would scarcely agree with Colonel Strange that the establishment of a large number of new additional institutions supported by the Government is required?—No.

10,517. You have stated that another or a supplemental observatory would be desirable, but in other matters you do not consider it very desirable that the Government should directly intervene?—That is very much my view. I think this may be laid down as a rule generally, that where you find that private persons feel so much the want of some series of observations that they undertake themselves to carry them on in series for a good while, then the Government may advantageously assist. With regard to two or three of these things that has been the case. The systematic observation of the spots on the sun has been carried on by Mr. De La Rue and others who have assisted him, partly at the expense of the British Association whilst the Kew Observatory was connected with it, and lately for some years at the private expense of Mr. De La Rue. I think that gives a stamp at once to the importance of the thing, and that it is desirable, after that, that systematic observations should be made by the public authority. It is nearly the same with regard to the results of the spectroscopic observations of the sun's limb. There are persons at the present time who are carrying on those without any special sanction. I do not think that there are very many in England, although Mr. Huggins is to some extent going on with them, but some foreigners are going on with them in a most systematic way, but quite independently of one another. In a case like that, where a thing has received the sanction of private labour and private expense, I think that the State may very well take it up.

10,518. Are there many specific instances in which it would be very desirable that the Government should lend assistance?—I think so; and I think that the criterion which I have mentioned would be a very good one. Whenever private persons think it a matter of sufficient interest to spend their money and time upon it, then I think that the Government may take it up.

10,519. Colonel Strange recommends the establishment of one or two extensive laboratories, a physical laboratory, and a meteorological laboratory; have you formed any opinion upon this proposal?—I am not sufficiently acquainted with it to be able to say. A great deal is done by private persons; indeed, if I may express my own opinion, there has been too much done by the Government in favour of astronomy hitherto, and too little in favour of other sciences, such as chemistry.

10,520. (*Professor Smith.*) You mean too much in proportion?—Yes, too much in proportion. But the mode of application in favour of such subjects as chemistry must always be considered as affected by my preceding remarks. On page 5 of his paper, Colonel Strange has pointed out some things, beginning with Faraday's opinion upon the choice of a metal, and he goes on to say that we are no nearer a solution than we were, which is quite true; but I do not see how that is to be promoted in the least by the establishment of an institution specially directed to metallurgical investigations. If Colonel Strange has felt the inconvenience of this uncertainty, he might work out a few experiments before he calls upon anybody else to do it. I think labour ought to begin at home in this matter.

10,521. (*Chairman.*) Have you formed any opinion upon the subject of a paid Academy of Sciences?—I have repeatedly thought of it, and it appears to me to be very much opposed to the genius of this country. I believe that it has been found necessary in Russia, for instance, where, without it, there would be only a set of barbarians, and it has been found undoubtedly of assistance in France, but it is quite the spirit of things here for persons to work individually, I think.

10,522. Would you apply the same opinion to the question of establishing a paid consultative council to assist the Government on all matters of science?—Yes. I do not think that they could do very much. There have been bodies of that kind from time to time. The Board of Longitude was a very useful body for a time, when the struggle was rising about accepting the theory of gravitation and generally introducing it, especially into the formation of lunar tables for the aid of nautical astronomy, and also the subjects connected with it; and that Board of Longitude undoubtedly did good service for a time, but somehow or other it died away; it became an object of contempt; there appeared no reason for keeping it up at any expense, and it was abolished and nobody seemed to regret it. [*See* APPENDIX VIII.] Then the Admiralty had an institution of three scientific advisers, but I believe the scientific advisers perished in nearly the same way after a time; and I think that so far as the experience of those bodies has gone it supports the idea that it will be better for the Government, when occasion requires it, to get the best advice that it can.

10,523. Do you see any inconvenience arising from the several scientific institutions that are more or less connected with the Government being under different departments?—Not that I am aware of.

10,524. You are content that the Royal Observatory at Greenwich should remain under the Board of Admiralty. You do not require to have a minister of science or a minister of education?—No, we are naturally connected in those respects with the Admiralty. The Observatory at Greenwich was not established solely for astronomy, but for astronomy and navigation. From the historical circumstances which led to its establishment it was entirely for navigation. The application of an observatory to the purposes of navigation implies so many wants of the highest part of accurate astronomy, that astronomy necessarily comes in with it as an adjunct which, perhaps, almost overwhelms the original; but, at the present time, there stands the inscription over the outer entrance to the observatory that it was made for the purposes of astronomy and navigation. I have always borne that

G. B. Airy, Esq., C.B., P.R.S.

26 April 1872.

in mind in the conduct of the observatory, interpreting it in the most liberal way; that is to say, that, in the first place, the observations of the moon must be carried out to the utmost possible extent, and I have extended them very greatly myself by new instruments and new methods. In the next place, objects such as were not contemplated in the original institution of the observatory, and had to be introduced, as, for instance, the improvement of chronometers and the extensive dissemination of time-signals, in both of which I have taken a great part myself. Finally, with all that, I have not neglected the purely astronomical part. But I mention that it is in that way that science has been introduced into the observatory from its connexion with a utilitarian subject, and I am inclined to think, from all that I see of the history of various observatories, that is the best fate that can happen to an observatory. It is supported in a better and more healthy condition from being connected with a subject of social utility than if it were left wholly to the abstract science of astronomy. I should have respect to that in a great measure in the establishment of anything else in such matters as the expansion of metals, the one to which I alluded just now; those investigations are better left, I think, in connexion with the subjects of the survey, when the subject of the expansion of metals enters in an important way into the choice of standards, and not to be taken up abstractedly.

10,525. Do you consider that the observatory is as closely connected with navigation now as at its original establishment?—Quite as much as ever.

10,526. The main object is still for purposes connected with navigation?—Yes.

10,527. Have you often occasion to make application to the Admiralty for additions or for the purchase of new instruments?—Yes, not unfrequently. During my time at the observatory I have completely remodelled the instruments; there is not a single instrument in use now which I found there, and has not been for many years; and new ones have come from time to time which are not connected with the subject of navigation. For instance, about two years ago a question was raised as to the effect which the thickness of the glass of the telescope, or, generally speaking, the quantity of refracting medium which the light had to go through, has had upon the magnitude of the coefficient of aberration of the stars. This was a question of some interest in astronomy, and it was one of great interest in physical science generally, especially as affecting the theory of optics; and the thing appeared to me so important that I planned an instrument expressly for the purpose of testing it, and I applied to the Admiralty for the funds. I think about 150*l.* was the expense of this particular experiment, and the Admiralty assented to it, and it was sanctioned in the estimates, and the matter has been carried out to a termination which is considered of very great importance to the science of optics in particular, but in no sort of way affecting those parts of astronomy which have relation to navigation.

10,528. Do you find the Admiralty always willing to attend to any representation that you make to them?—Yes; I have had no reason to complain at all of the liberality of the Admiralty.

10,529. (*Professor Smith.*) I think you have intimated that the demands upon the time of a person occupying an office such as your own are such as to interfere seriously with the time he might have for a philosophical investigation?—Yes, they do.

10,530. Do you think it would be possible that, in your and similar offices, arrangements should be made to give more time to a scientific man for original research?—I think it very possible that the larger an establishment is, the more time may be left at the disposal of the head of the establishment. I think that it necessarily induces new organizations which can be made more efficient for the purpose of relieving the person at the head.

10,531. So that in fact the larger the scale of the establishment, the better prospect there would be of a relief to the head?—Yes, that is my belief.

10,532. Do you think that the Universities could do anything to encourage young men, after they have taken their degrees, to follow out lines of physical research and inquiry?—Apparently there is great difficulty in that. That was a point which I urged very much in the correspondence which I had with the then Vice-chancellor, the Master of St. Peter's, and with other persons, but they seemed to think that there would be great difficulty about it. It is commonly conceived in the University that there is no way of carrying out any branch of study except by examinations, and it may be justly so as a matter of fact; but men grow tired of examinations, and become disgusted with them, and would rather keep away from them. I think that after the time of their taking the bachelor's degree they must be left to themselves in a great measure, and I think that all that can be done by that time must be in the promotion of habits of a rather different kind from those which are now promoted. Less book work and manuscript work, and more attention to instruments.

10,533. But do you think that at the present time the Universities do supply sufficient opportunities of that kind to eminent students?—No, there have been very few opportunities of the kind indeed. I am inclined to think that that is one of the subjects in which something of the professorial system might come in with advantage, and I think that it would be well received by the students. On one occasion when I examined for the Sheepshanks' Exhibition at Cambridge, which is exclusively astronomical, I carried with me some of my instruments, theodolites of a good construction, and transits, and others; and by way of examination I put my candidates through the adjustment of those things in a way which was sufficiently accurate to test their acquaintance with the principles of the adjustments, and they took great pleasure in it, and they all went through the examination with interest. That showed me very accurately how much they knew of the practical application of those things, and from what I observed then I am well convinced that many of the best students would with great interest enter into the subject of a more practical acquaintance with philosophical instruments.

10,534. Is it not the case now that if a young man at either of the Universities should wish, after he has taken his degree, to follow out any line of physical research, he would have great difficulty to find a place to work in, or in obtaining, without going to very great expense, the proper apparatus to work with. He would be in nearly the same difficulty, would he not, as if he did not belong to the University at all, for the University does not supply him, either with a place to work in, or with a collection of apparatus available for it?—It is so. He would find himself in great difficulty.

10,535. Do you not think that the progress of science might be promoted in that direction by the Universities?—Very much indeed. I think that there is a great responsibility upon the Universities, that they are truly the fountain from which everything good in the way of education can flow into the country, and that they have been established for that purpose, and that there is a responsibility upon them, and one which can be carried out with great advantage to the country, I think, in the particular way which you mention, by providing apparatus and instruments and accessibility to them.

10,536. I quite agree with the principle which you have stated that "labour ought to begin at home," but might not the Government, as well as the Universities, do something in the same way for the scientific world by providing a great physical laboratory, not for researches to be undertaken by order, but in which facilities should be given to scientific men, because, to be an experimental physicist, in the present state of science, requires a large expenditure of money?—The Government Grant Committee will do a great deal in that way.

10,537. But you so often want a *locale* for physical experiments, as well as grants simply of money?—Yes, there is a difficulty in finding a locality. The observatory at Kew was taken up by the British Association some years ago mainly for objects of that kind, and when it was abandoned some short time since by the British Association, I remember once especially a special inquiry was made of me by the council of the Royal Society, whether I thought the Royal Society ought to keep possession of it for experimental purposes, and I gave it as my opinion that certainly I thought they ought, as there was no other place available; but it is a long way off, its distance is inconvenient; but where are you to find a place in London that would do? It really is not easy to find one, and especially when you consider that wherever it is, it is away from the residence of the person who is to use it, and that probably for the greater part of its time it would be of no use at all—it would be standing idle; for those considerations I would prefer giving assistance in the way that the Government Grant Committee gives it, namely, to the person who wants assistance, to be employed in the way which he finds most convenient to himself.

10,538. It is the case, is it not, that some of the physico mathematical subjects which were not introduced into the Cambridge examinations have quite recently been introduced into them?—I am not quite sure. If you mean within four or five years, I am unable to say. I do not think I have seen the Cambridge examination papers, except the Smith prize paper, for a short time. I used to see them constantly at one time, because I had my three sons in succession at Cambridge, and I used to see the papers regularly, and sometimes I applied for more; but I think that, though I have kept up a close connexion with Cambridge, I have not seen them for one or two years past, and therefore I am somewhat unable to say.

10,539. (*Chairman.*) Are there not some changes coming into operation at the next examination?—Yes, some changes are to come into operation, I believe, at the next approaching examination.

10,540. (*Sir J. Lubbock.*) You have expressed an opinion rather adverse to any idea of any paid academy in this country, as not being adapted to the habits of the English?—Yes, that is my general opinion.

10,541. I presume that you would not advocate any closer connexion between the scientific societies and the Government?—No, I would not. I think they stand very well as they are. The members of the societies subscribe cheerfully sums to such an extent that the societies are able to undertake some enterprises of their own, as, for instance, the Astronomical Society are at this time preparing to publish at considerable expense, and at their own private expense, accounts of the eclipse of 1870 and with some portions of the one which preceded it, the eclipse of 1860; and under the feeling that this was done by their private efforts, private members have taken a part in it which we could not get done before; positively, the observations of the eclipse of 1860 remained shut up in my closets, and it was impossible to find people who could undertake the enterprise of putting them in order; but now that the question was broached of how to publish the eclipse of 1870, as soon as the society had determined that they would publish it at their own expense, without asking Mr. Lowe or anybody, persons arose to give their personal labour to the preparation of the account both of that eclipse and of the eclipse of 1860, which preceded it. I think there is a great deal in that spirit; that when a private society undertakes to do a thing without demeaning itself to ask the aid of Government, there are persons amongst its members who will make extraordinary efforts themselves.

10,542. Is it your impression that that answer is one in which the majority of the scientific men of this country would entirely coincide?—I think so.

10,543. The Government, when it has occasion for scientific advice, is sometimes in the habit, is it not, of consulting the Council of the Royal Society?—Yes, repeatedly, as for instance, a very short time ago the Government consulted the Council of the Royal Society about a circumnavigation and dredging expedition in extension of that which Dr. Carpenter had done.

10,544. You would consider, would you not, that the Council of the Royal Society was the best body to which the Government could have recourse in any matters of that kind?—Yes, and I do not know what better rule could be made.

10,545. What is the number of the council of the Royal Society?—Twenty-one, including the officers.

10,546. I think the ordinary members of the council usually change every two years?—Yes, one-half of the ordinary members.

10,547. Do you not think it might be desirable, considering the very important functions which that council has to perform, that the change should be less rapid?—Yes, I think that would be advantageous.

10,548. On that point you think it might be desirable to have an alteration in the system?—I think the change should not be so frequent certainly. But, on the other hand, in a large society, it is difficult to avoid the demand for frequent change.

10,549. Do you not think it might also be desirable perhaps to increase somewhat the number of the council, considering the very great division that there is now between the different branches of science?—Probably. It is felt sometimes that the grasp of the Royal Society is too large, and I think it possible that for special subjects the Government might perhaps do better than apply to the Royal Society. On an astronomical subject I would rather take the advice of the council of the Astronomical Society than that of the Royal Society, and so probably it would be for other subjects.

10,550. But assuming that they go to the council of the Royal Society, I rather gathered from your answer that you think it might be desirable that that council should be somewhat more numerous?—Yes, abstractedly; but you cannot ensure the attendance of a numerous body so well.

10,551. I do not contemplate what you would call a numerous body, but perhaps if it were 30 instead of 21 it would be an advantage?—I think with the present number every member of the council feels upon himself the responsibility of attending on every occasion, but that would not be so, I think, if the number were much enlarged.

10,552. But if the tenure of office of the council of the Royal Society were somewhat prolonged, unless the numbers were increased, it would be a long while, would it not, before a gentleman would come to serve a second time on the council?—Yes, it would.

10,553. And in that way his experience would be lost?—Yes, but there really does exist the inconvenience arising from the cause which I mentioned that I think the grasp of the society is too large.

10,554. Although the attendance probably would not be quite so close, if the numbers of the council were larger, yet when any case was coming forward which had reference to any particular branch of science, those members particularly connected with that branch would of course make a point of attending?—Yes; that might be so.

10,555. (*Dr. Sharpey.*) With regard to the short tenure of office of the members of the council, it is the practice, is it not, when 10 new members are introduced into the council annually, to select five who have been in the council before?—Yes, I believe it has been so.

10,556. So that the rule which has been adhered to for some years is to take five members who have previously been on the council, and five who have not been on the council, the latter number being selected with a view to giving an opportunity, in the course of time, for a considerable number of the fellows to serve on the council?—Yes, and a regular succession kept up.

10,557. Of course you are aware that by the constitution of the Royal Society, its government, including the framing or altering of statutes, is absolutely entrusted to the council, and probably it may have been deemed advisable to afford a means of control to

G. B. Airy, Esq., C.B., P.R.S.

26 April 1872.

the society at large by more frequent change of the members of the council?—Yes, that is a necessary part of the policy, no doubt.

10,558. With regard to the extension of the numbers of the council of the Royal Society, some questions might doubtless arise requiring for their solution the aid of men who might not be included in the 21 members of council, but is not that difficulty in a great measure got over by the appointment of committees, which need not be composed exclusively of members of the council, but of the fellows of the society selected on account of their acquaintance with the particular question at issue?—Yes. Some years ago there was a considerable system of committees of the Royal Society on different subjects. I am now referring to the appointment of committees as occasion arises, and that could be done with great advantage.

10,559. That is the common practice of the council, is it not?—It is, for instance, in the case of the dredging expedition to which I alluded; and I think it would be very useful as occasion arises.

10,560. (*Chairman.*) Are you acquainted generally with the progress of science on the continent?—Yes, tolerably so.

10,561. Are you of opinion that more important researches are made among the continental nations than at home?—In proportion to the population I do not know that there are. Some things have been taken up with greater vigour, for instance, I think spectroscopy has been taken up more actively on the continent than in England.

10,562. Generally speaking is not much more done by the State in foreign countries than in England?—Yes.

10,563. Are you of opinion that the results are greater in consequence of the great assistance provided by the State in foreign countries?—In that particular thing which I mentioned, spectroscopy, much more has been done certainly on the continent than in England; but perhaps when we say that it has been done by the State, that might in itself convey an impression which is a little incorrect. It is chiefly the work of persons who cannot be said to be in a private position. For instance, the most that has been done in the physics of the sun has been done by Secchi, who is a Jesuit in the Collegio Romano at Rome. He is not in the position of a private person, but still he is not in the position of a person paid by the Government for science. I think, then, something has been done by Zöllner, and some others in Germany, and there I believe the professors in the Universities are not paid in any other respect than as University Professors.

10,564. The University funds, generally speaking, on the continent are provided by the Government, are they not?—Yes, they are provided by the Government. I think there is a little want of leisure amongst men of science in England. Men of science generally are practical men engaged in some way or other in gaining their livelihood by their daily work, and there is less of the class of leisurely scientific men in England than elsewhere.

10,565. Do you think that an evil for which it would be desirable to provide a remedy?—No, I think it would become liable to great abuse. I do not wish to see it very much. If members of privileged bodies who have no very precise duties, would consider science as one of their responsibilities, I think that something might be done; and that would be nearly the position of Secchi, at Rome, who is an ecclesiastic not bound to any particular duties except the duties of his office.

10,566. Do any other points occur to you on which you would like to make any additions to your evidence?—Nothing occurs to me at present.

The witness withdrew.

J. P. Joule, Esq., D.C.L., F.R.S.

JAMES PRESCOTT JOULE, Esq., D.C.L., F.R.S., examined.

10,567. (*Chairman.*) I believe that the advancement of science is a subject to which you have paid considerable attention?—Yes, I have paid some attention to it.

10,568. Are you of opinion that in any direction the assistance of the Government could be advantageously given to a greater extent than at present in advancing science?—Yes, I think in the first place that there might be observatories in a greater number of localities, supported by the State, in which there could be continuous records made of such phenomena as solar spots, and for the purpose of obtaining simultaneous observations of meteors, and also of earthquakes. Those are subjects for which it is essential to have observatories at considerable distances from one another, in order to obtain good results. Then, I think, with regard to the sea level and the tides, although the laws with regard to the tides are pretty well known, they ought to be continuously observed, if only for the purpose of registering the changes arising from the alteration of banks, depth of channels, &c. Also with regard to the sea level, there have been reports from time to time with regard to the inroads of the sea on our coasts, but sufficient steps do not appear to have been taken to ascertain the facts in those cases. It seems to me very important to be acquainted with any alterations in the configuration of the earth which may be taking place, however minute those alterations may be.

10,569. With regard to these observatories which you suggest, there are, I believe, at the present time, certain meteorological stations?—Yes.

10,570. Do they fall short of what you think desirable?—I think so.

10,571. Both in point of number and in the objects on which they are employed?—The meteorological observatories have no reference, I think, to such phenomena as the solar spots or meteors, they principally take notice of atmospheric changes with reference to winds, the temperature, the barometrical pressure, and the like.

10,572. Do you consider that several observatories in this country supported by the State are wanted for the continual watching of astronomical phases?—I think it would be desirable to have more than we possess. I think, for example, that it would be desirable to erect an observatory in the neighbourhood of Manchester.

10,573. Would the observatories which you would suggest for watching the tides and sea level be upon a considerable scale; would they require much apparatus?—I do not think that such observatories would require any enormous expense. I suppose with regard to the sea level, that all that would be necessary would be to authenticate certain marks of reference to begin with. There are such points marked, I think, on various points of our coasts.

10,574. Under whose superintendence are they?—I mean to say that the positions of certain points of reference on various works in connexion with docks or other works may be a basis for future observations, as to the amount of difference with regard to the height of water.

10,575. Do you think that it would be desirable that at certain stations arrangements should be made for continuous registration?—Yes, of the tides, and to obtain a permanent record of what the sea level is in relation to the land.

10,576. Would that be a work which ought, in your opinion, to be carried on from day to day by a permanent establishment at such places?—I am not exactly in a position to say to what extent the labour would be. I am not sufficiently acquainted with the subject of measuring tides; but I believe that self-registering apparatus have been devised which would enable the mean sea level to be registered, and the tides to be registered, without very much trouble.

10,577. Is it a sort of work which can be carried on by public officers stationed at any of the ports, or

J. P. Joule, Esq., D.C.L., F.R.S.

26 April 1872.

would you require a separate staff?—Probably it might be carried on by the officers at the stations. I do not think it would be necessary for anyone to be exclusively occupied in such a work.

10,578. What is the next object to which you believe State aid could be advantageously afforded?—The next object is museums. I think that they are extremely useful institutions, and it seems very desirable to have them both numerous and very accessible. Even if they were incomplete, they would be most valuable means of assisting students and inquirers generally. The things which I think would be desirable in museums are specimens in natural history, specimens in chemistry, specimens in geology and mineralogy, manufactured products, machines, tools, &c., scientific instruments, patented inventions, and historical instruments.

10,579. Is it your opinion that museums ought to be provided by the Government in several parts of the country, or would you think that sufficient would be done if the Government gave some assistance to local efforts?—I think that assistance to local efforts would be all that would be desired. In some towns museums might probably be supported to a certain extent by means of a rate.

10,580. Libraries can be established in that way, but are you aware whether that is the case with museums?—I will not be quite sure about that.

10,581. Are you acquainted with many local museums?—There are small museums in the public parks of Manchester, particularly in Peel Park in Salford. These are growing and becoming of more use, I think, by degrees; but still assistance would no doubt be very desirable in order to make them more perfect, so as to be more useful to students. The museums which belonged to the Natural History Society and the Geological Society were entirely established by private benefactions.

10,582. Are those valuable museums?—In their own departments they are very complete. They now belong to Owens College.

10,583. Would you place those museums under the supervision of the Government in any shape, either by appointing inspectors, or by any other method?—I cannot say how far the Government should intervene. Of course, if the Government contributes funds, it has a right to superintend in some measure and control the way in which those funds are expended. I think that the real assistance would be by the encouragement of giving a certain grant of money. I think that the towns themselves would be able to carry them on with a certain amount of pecuniary aid.

10,584. Under what management is the Salford museum of which you have spoken?—It is under the management of a committee of the corporation.

10,585. Is it satisfactorily managed?—I think so.

10,586. You attribute, do you not, a great deal of importance to the establishment of museums in a good many large towns?—Yes, I do. No one can deny the importance of the British Museum, but of course vast numbers are not able to visit it at all; and then, those who are able to visit it cannot in many cases spend sufficient time in it to obtain much advantage. Very large institutions are often used too much as show places, whilst smaller collections would probably be quite as advantageous to the inquirer. With regard to specimens in chemistry, a chemist will take very great trouble in preparing a paper describing certain chemical products, and all of those products may be lost, and no one may be able to examine them again, or to see them without going to the trouble of manufacturing them for himself. With regard to scientific instruments, it is a very great advantage to have an opportunity of merely seeing what has been done in the way of making scientific instruments. Seeing an instrument enables you to form a judgment to a certain extent as to what you may require for other purposes, perhaps, than those for which the instrument was intended.

10,587. Are scientific instruments kept in the museums at Manchester and Salford?—There is in the Philosophical Society of Manchester a collection of scientific instruments which belonged to the late Dr. Dalton.

10,588. But it is not kept up; additions are not made to it?—No.

10,589. (*Professor Smith.*) Those are historical, are they not?—Yes, those would come under the head of historical instruments.

10,590. (*Chairman.*) Are there any local museums that you are acquainted with that come up to your idea of what a good museum should be?—No, they are not sufficiently comprehensive. For instance, in the Manchester museums there are collections in natural history and in geology, but nothing to speak of in chemistry; and there are not manufactured products, nor are there machines, or scientific instruments, and they are also deficient in patented inventions. The necessity of having patented inventions displayed is a subject which has been very often mooted.

10,591. You think that such museums could not be established without Government assistance in some form?—It is my opinion that Government assistance would be an immense stimulus; a sum of money being given, it would certainly operate upon local bodies and town councils, which would see that it was supplemented with voluntary contributions, and I think there would be a spirit of emulation among the different towns in improving their respective museums.

10,592. Would you limit such assistance to towns of a certain population?—I am not prepared exactly to say what population would demand a museum. It is a question, I think, which involves various considerations.

10,593. Many small towns are often anxious, are they not, to get up something of the kind?—Yes, they are; and if there is such an anxiety, I should say that that anxiety ought to be rewarded. With regard to the localities for museums, there are many localities which may not be very populous, but at the same time they may be very highly interesting districts. They may abound, for instance, in mineralogical treasures, and interesting in a geological point of view; I think it would be especially desirable to have museums for those objects which exist in the various localities.

10,594. Not necessarily embracing all the objects which you have mentioned?—No, I think not. In fact, with regard to some of them, for instance, with regard to patented inventions, probably it would be sufficient to have only one museum on that subject, because anyone interested in a patent would not much mind taking a long journey in order to see whether he had been forestalled in his invention.

10,595. Is there not in London a museum for patents?—Yes, at South Kensington, and that probably would be sufficient if it were complete. The great object in a museum of that kind is to have it complete and properly classified.

10,596. What is the next object to which you would refer as wanting Government aid?—Libraries of books. I know the difficulty that there was even in so large a town as Manchester to obtain access to a copy of the Philosophical Transactions something like 30 years ago. I believe there was no public library which contained a copy of the Transactions excepting the Chetham library. The Manchester Philosophical Society possesses them now, but it did not at that time.

10,597. Does Manchester possess many of the foreign Transactions?—We have now an excellent library belonging to the Literary and Philosophical Society, this was greatly increased by the zeal of a former librarian, Mr. Ekman, who instituted a correspondence with all the societies which then existed; and the consequence is that we have now a very excellent library of Transactions, both foreign and British.

10,598. Then, so far as Manchester is concerned, not much more is required?—The want is now supplied in a great measure, for although the library of the Philosophical Society is the property of the members, anyone can readily gain access to the books. It is a library of about 12,000 volumes.

10,599. Are you beginning to have any difficulties

J. P. Joule, Esq., D.C.L., F.R.S.

26 April 1872.

with regard to space?—Yes, we have difficulties with regard to space, and those also involve difficulties with regard to funds; so that in fact we have experienced considerable difficulty in carrying on the society.

10,600. It is not attached to Owens College, is it?—No, it is entirely separate. It is the oldest of the provincial societies, having been founded in the year 1781.

10,601. Have you any acquaintance with libraries in any of the other large towns?—No, I cannot say I have.

10,602. It is an object for which you would like to see some Government fund provided?—I do. I think that in some neighbouring towns about Manchester it would be very desirable if better means were provided for consulting scientific publications, and I think also, on the other hand, that libraries are a means of preserving scientific works, because if merely in the hands of individuals it is very possible that the Transactions of some societies may be lost, whereas if they are kept in public libraries I think they have a far better chance of being preserved. I have at times bought in shops part sets of various scientific serials, and it seems to me that the very existence of Transactions in incomplete sets in the shops shows that the preservation of the books is imperilled if they are solely in the hands of individuals. At the present moment the Philosophical Transactions are very extensively circulated, but I am alluding to many other periodicals which have not such an extensive circulation, and if they were merely in the hands of individuals probably the valuable papers contained in them might ultimately be lost.

10,603. Will you go to the next object?—I think it is desirable to continue the publication of complete classified catalogues of scientific researches such as the Royal Society has been engaged upon, and which would require a continuance of funds for the purpose. The Royal Society's Catalogue goes from 1800 to 1863. I think it would be very desirable that the Government should bear the whole of these expenses.

10,604. (*Dr. Sharpey.*) Are you aware that the Chemical Society is at present engaged in printing classified abstracts of the contents of periodical scientific works published throughout the world?—Yes, but it is a costly undertaking.

10,605. It might be very greatly aided, might it not, by a grant of money?—No doubt, and that is only for one department of science.

10,606. Does that case come under your view as deserving of Government aid?—Yes, quite so.

10,607. (*Chairman.*) Will you proceed to the next head?—With regard to scientific researches the aid given by the British Association and the Government grant dispensed by the Royal Society are of very great value, no one can doubt that, but they do not include personal expenses. Personal expenses are not covered by this assistance, and a very large proportion of the cost of researches has to be incurred by the inquirers. The Government might render help by giving such sums to the Royal Society, to the British Association, and to other bodies, as would enable them to give adequate grants so as to cover entirely the expenses of inquiries.

10,608. Are you acquainted with any instances in which such researches have been obstructed from want of sufficient assistance?—I may say this, that the researches which I have myself made involved the obtaining of buildings, and there were various expenses which I could not fairly put down to charge against a grant given for the inquiry. It is understood that a grant does not cover personal expenses, and thus it may happen that not a quarter of the real outlay will be paid for by it.

10,609. Have there been instances in which the Manchester Philosophical Society has applied to the Royal Society, recommending objects to which a portion of its grant might be applied?—No. The applications come from individuals and not from bodies; at least I am sure that our Philosophical Society has never made application.

10,610. Would you suggest that a local society should apply directly to the Government for assistance?—I think there would be an advantage in that, supposing those local societies had sufficient claims to warrant their applications, that is supposing those societies were properly constituted scientific societies, not merely debating clubs, or anything of that kind.

10,611. (*Professor Smith.*) You do not find any complaints, do you, that grants are not obtainable from the Government fund administered by the Royal Society?—No, I never heard of a complaint, but it is always understood to be a very limited sum.

10,612. Has it occurred to you that some of those expenses to which you have referred might be saved if the local societies were in possession of laboratories, or rooms in laboratories, which they could place at the disposal of inquirers, and also collections of apparatus that might be rendered available to them?—I think that would be very desirable indeed.

10,613. In your own case, do you suppose that an arrangement of that kind would have been of any service to you?—Most certainly. I had very great difficulty, in fact a research that I was making with Sir William Thomson was stopped simply because the owner of the Trafford estate threatened legal proceedings if I used a one-horse power steam-engine which was a necessary portion of the apparatus; so that I was compelled to discontinue the experiments because I was unable to go to the expense of purchasing another plot of ground, and re-erecting the requisite buildings.

10,614. So that, in fact, it really is, you may say, very often impossible for a man to have, even if he can afford it, a physical laboratory in a private residence?—It is, even if the private residence be absolutely detached, as it was in my case.

10,615. Do you not think that this circumstance renders it imperatively necessary that there should be public institutions in which such facilities could be obtained?—I do think so, and particularly for young inquirers.

10,616. You are of opinion that opportunities should be given to young inquirers, who have shown that they have sufficient education in science for the purpose, to undertake and carry on investigations?—I do most decidedly think so; I think that a young man is liable to spend money without judgment at the beginning of his scientific career if he is left entirely to his own devices, and at that time it is most important that he should enjoy the assistance and guidance which would be afforded by a public institution.

10,617. Do you think that scientific apparatus could really be made use of in that manner without excessive risk to it?—I think so. In fact, the burden of the risk might be on the individual; he might be responsible, at any rate, to a certain amount with regard to it.

10,618. And there are many kinds of scientific apparatus which are available for a great many different researches, and which are used again and again?—Yes, and it is sometimes very desirable that the same instruments should be used in various researches. It seems to me also very important that facilities should exist for obtaining the loan of instruments.

10,619. So that, besides the waste of money, there is a positive disadvantage in each inquirer having to start a little cabinet of physical apparatus of his own?—I think so; and besides, very frequently he may use imperfect instruments from imperfect knowledge of the subject, or motives of economy.

10,620. (*Chairman.*) Has the Manchester Philosophical Society any collection of philosophical instruments?—None whatever, excepting what we may call the historical museum and some microscopical apparatus.

10,621. (*Professor Smith.*) Do you know of any collection of scientific instruments in this country which, in the least, meets the object which you mentioned just now, that of enabling persons to see them and examine them?—I do not know of any considerable collection accessible to the public.

10,622. (*Dr. Sharpey.*) You are not aware of any

J. P. Joule, Esq., D.C.L., F.R.S.

26 April 1872.

collection of instruments that might serve as examples of the most advanced condition of apparatus?—No; I never saw one.

10,623. Supposing there were laboratories established in connexion with the scientific societies to which you have referred, where opportunities would be afforded for cultivators of science to carry on original research, have you no apprehension that they might come to be idle, or, at least, not be sufficiently used?—I should hope not.

10,624. You would think that there would always be a sufficient demand for the opportunities that those institutions would afford?—I think so. I think that the fact of the existence of such means would be a certain stimulus to inquirers. I think very often an inquirer is nipped, as you may say, in the bud, simply because he does not find that he can conveniently, or at all, carry out his investigations.

10,625. Under what authority would you admit persons to work in those laboratories?—I should say that a man ought to be sufficiently instructed, so as not to play with the things.

10,626. Would you place them under the government of the local institutions?—If possible I would do so. I think they would be near at hand, and generally able to take charge of them.

10,627. And that they could regulate the admission?—I think that a society like ours in Manchester would be quite adequate to superintend such work as that.

10,628. (*Professor Huxley.*) Under what regulations would you place the persons who might work in those museums, for example, who should have the power of determining whether anybody who made application to work in a physical laboratory should work there or not, and again as regards the length of time during which he should work?—I am afraid in the first place there would be no very great press of labourers. I think that a difficulty would not arise with regard to limiting any individual because he would run counter with another.

10,629. But that is a difficulty which would have to be contemplated, I imagine; it is one which might very readily arise, as, for example, we all know there are unfortunate rivalries amongst people, and it might be that a person who was opposed to the views of somebody else should wish to employ the apparatus of a laboratory, while his opponent might be wanting to do so, and there must be somebody that would have the power of control?—Probably the Local Scientific Society would be sufficient for that. So far as my own experience of the Manchester Philosophical Society goes, it would hold an even balance between all parties.

10,630. Would not you have a superintendent of the laboratory who should have charge of it, or would there be any efficient responsibility, do you think, without some particular person who was responsible?—I think if it were a large institution it would be necessary to have a superintendent. Much would depend, however, upon the extent of the affair.

10,631. But surely in the case of a laboratory extending to any size beyond what might be provided by a private body, there must be some one to see that it was in order, and that it was properly employed and that no improper use was made of it?—I think that the local society would generally be able to undertake that duty.

10,632. You think they would have authority enough?—I think so; or if the Government gave the funds it would in all cases, I apprehend, use its own inspection and probably inspect reports of what was being done.

10,633. You were speaking just now of the payment of personal expenses, do not you think that there is a great deal of practical difficulty about that, and that if a grant once became the means of defraying personal expenses it might be made a source of income to the persons receiving them?—I believe it would be like everything else in this world, liable to abuse, but I think on the whole that scientific inquirers who are losing the time which might be more profitably occupied in business, even if their personal expenses were paid, would always be losers in a pecuniary sense, and therefore, I think, we may give credit to them for sufficiently high principles to prevent them abusing the grant, and it would be the exception if anything of that sort happened.

10,634. (*Chairman.*) Have you any remarks to make on the subject of the verification and issue of scientific instruments?—I think that that ought to be placed under some authority, for it is of the greatest importance that correct instruments should be used, and I think that by the application of the funds of Government it would be possible to supply instruments of the best description, at the price at which instruments of an inferior description have been often sold, and which have been bought for the sake of economy.

10,635. Would you recommend that Government establishments should be formed for the manufacture of philosophical instruments?—Kew has done much towards providing them.

10,636. Do they make instruments at Kew?—Some have been made there, I believe. The thermometers were generally blown, I believe, in town, but entirely under the direction of the establishment at Kew, which has also verified thermometers and barometers sent there for the purpose. I have obtained thermometers from Kew, and so has Sir William Thomson, and nearly everyone engaged in thermometrical inquiries has obtained his instruments from Kew, and the loss of an authoritative institution for issuing those instruments would be very serious.

10,637. If you were to extend the establishment to the supply of scientific instruments generally of all descriptions, it would require to be on a very large scale, would it not?—It would. The general idea is that there should be some authority to whom to apply, so that imperfect instruments should not be made use of by inquirers, and that there should be no excuse for making use of inferior instruments.

10,638. Would you propose that the purchasers of instruments from the instrument makers should have access to a Government establishment in order to ascertain whether the instruments were accurate or otherwise?—I think that very desirable.

10,639. With regard to scientific expeditions, there have been a certain number of such expeditions undertaken by the Government, have there not?—Yes.

10,640. Do you think it is desirable that they should be carried on on a larger scale, or more frequently?—I think so, and that they should be planned without hurry, and without the necessity of a fresh canvass for funds on each occasion which arises. I believe difficulties have arisen, because it was not certain whether the Government would give assistance in funds to an expedition. In such cases, even if the assistance were ultimately given, it might be afforded so late that the expedition would be got up in too great a hurry to fulfil all which was expected from it.

10,641. What arrangements would you suggest for that object; should there be a regular department of the Government organised to consider such questions?—I think that if the Royal Society, for instance, were to make a representation to the Government that it would be desirable to send out an expedition, it would be an advantage if it were understood that, as a matter of course, the Government would give funds to carry it out.

10,642. In those expeditions which you speak of, would you include expeditions undertaken by the Admiralty surveying vessels, or vessels employed for scientific purposes?—I was not thinking of those; I was thinking principally of those which would be sent out to observe eclipses and transits, and so on. At the present moment we ought to know whether there should be an eclipse expedition in 1875, in order that the instruments may be got ready.

10,643. (*Dr. Sharpey.*) What you refer to is, that when phenomena are only of an occasional kind, there should be some security that adequate means would be provided in time to observe them?—That is my view.

J. P. Joule, Esq., D.C.L., F.R.S.

26 April 1872.

10,644. (*Chairman.*) What security would you recommend?—I have not considered that subject.

10,645. (*Dr. Sharpey.*) Are you aware that the Astronomer Royal has already got arrangements in preparation for the transit of Venus, which will not take place till 1874?—Yes, but it was uncertain at first whether Government would lend its aid.

10,646. (*Chairman.*) Have you any suggestions to make with regard to inquiries for the Government respecting national defences, mines, adulterations, sanitary matters, sewage, and so on?—They may seem to be improperly included in a scheme for the advancement of science, but at the same time they are inquiries which from year to year assume more and more of the nature of scientific investigations, and to that extent ought to be in the charge of scientific men.

10,647. What sort of a body would you think such inquiries ought to be committed to?—One in which there is a large scientific element; and I think that to the same body might be committed the complete registration of disease and mortality, classified as to occupation, age, locality, meteorology, &c.; and also the registration of the diseases of animals, and of the blight of crops. We require something more, I think, than what is done at present; for instance, instead of obtaining the salubrity of a district, we require to know the salubrity of each street or even house before much can be done with regard to sanitary reform. The death rate in Broughton, one of the suburbs of Manchester, is less than one half that of the town itself, and yet I know that there are certain terraces of houses there which would stand very high indeed in the list if they were taken separately, so that it seems to me that medical men are under considerable disadvantage if statistics are not very elaborate. The whole question seems to me a matter of the last importance, and should be carried out much more completely than has been done hitherto.

10,648. (*Dr. Sharpey.*) By Government means do you suggest?—Yes. Private means are quite insufficient for a purpose of that sort. I have with me some tables of disease, got up by Mr. Ransome (*handing in the same*) for the Sanitary Association of Manchester. But continuous and systematic registration can hardly be expected to be carried out by unassisted local efforts.

10.649. Are you aware to what extent that is now done through the Registrar General's office?—I do not know. I know that a pretty thick volume is published.

10,650. But it is more a register of deaths than a register of disease?—Yes. The prevalence of disease is another point, and probably the more important, because it is disease leading to death.

10,651. You are aware, are you not, that that is a subject which is at present occupying much attention by public bodies, the College of Physicians and others?—Yes.

10,652. With a view to facilitate returns of a homogeneous character, some two or three years ago the College of Physicians suggested a common nomenclature of diseases, which was printed at the public expense and circulated to medical men all over the country; do you think that that should be carried further, so as to obtain statistics of the prevalence of different diseases?—Yes, I do. I think it is impossible to carry out the registration too completely.

10,653. Do you think that the local officers of health might be employed for that purpose?—I think they might with further assistance. It would require a great deal of extra work to carry it out; but it seems to me that a medical man who is occupied with the most intricate of all scientific questions has no chance whatever unless he has data of a very extensive description to refer to.

10,654. (*Chairman.*) Do you think it desirable that the Government should offer rewards for discoveries, inventions, and researches?—I think that a small sum of money in recognition of scientific labour would be in many cases a most useful help as well as a great encouragement, and if the patent laws are retained they might be supplemented with provisions to meet the case of those discoveries to which the patent laws do not apply.

10,655. There have been occasional instances, have there not, in which some very remarkable discovery has been acknowledged by the State in some shape or other?—Yes.

10,656. You are not aware of any instances of reward having been given for discoveries?—As a rule not, and in fact so far as the patent laws go they are useful to those who apply the discoveries of other people.

10,657. Is there any system of the kind on the continent?—I am not aware of any.

10,658. (*Dr. Sharpey.*) You are aware that there are cases where scientific discoveries which have been directly applied for public purposes have been rewarded by grants of money; for instance, Sir William Snow Harris's improvements in lightning conductors for ships?—Yes. Sir W. Harris was rewarded for introducing Mr. Henley's ship conductors.

10,659. (*Chairman.*) But they were all cases where the discovery was applicable to public purposes?—Generally; and it seems to me that in all those cases there ought to be some principle or some rule to guide those in power to say whether a reward is desirable or not, and to what amount.

10,660. (*Dr. Sharpey.*) Had not the late Mr. Faraday a pension from Government?—Yes, and so had Sir David Brewster, Dr. Dalton, and some others.

10,661. Have you any view as to who should advise the Government in cases of that kind?—I think a body like the Royal Society would be competent.

10,662. Would not it be rather an invidious duty to impose upon the Royal Society?—I think that a Board of Science might be created to which the Royal and other societies might suggest fit recipients of public rewards. I do not think that the various objects to which I have adverted could be efficiently carried out without the superintendence of a new department of State, the members of which should be men of science.

10,663. (*Chairman.*) If any such scheme as you have suggested were entertained, are you of opinion that valuable aid could be obtained from existing societies?—I think so. I think it might be obtained from the Royal Societies of London and Edinburgh, and the Royal Irish Academy, and from some local ones, for instance, the Literary and Philosophical Society of Manchester.

10,664. The assistance which could be afforded by the societies would be in the shape of advice, I presume?—Yes. By advising the Board of Science.

10,665. Are there any other ways in which the societies could assist?—Yes, in the superintendence of museums, the collection of libraries at different places, and probably the superintendence of observatories.

10,666. As science advances, are you of opinion that the necessity for State aid becomes more pressing?—Yes, I think it does. Processes become more complicated, and require a greater amount of outlay on the whole as science advances. The time was when valuable discoveries in chemistry were made by the use of washing utensils, but now, of course, the apparatus of chemistry is of a more elaborate and costly nature.

10,667. If any suggestions of the kind were made to the Government, it is not improbable that the answer would be, that too much State aid would not improbably tend to damp private efforts. Do you think there is any truth in such an opinion?—I do not think it is at all likely that private effort would be swamped by State aid, at any rate by the amount that would be given. I think none of us would wish extravagance. What we want is the means of work, and useful work too. I believe that the assistance of the Government would tend rather to encourage than to damp private effort.

10,668. (*Mr. Samuelson.*) You say that you would be glad to have museums for the purpose of collecting machines and tools, and also for patented inventions; do you think it would be desirable to separate the patented inventions from those which are not patented,

J. P. Joule, Esq., D.C.L., F.R.S.

26 April 1872.

or would you prefer that the different appliances, whether they be machines or series of appliances for chemical processes, for instance, should be classified according to the nature of the inventions, or according to whether they were patented or not?—In a general museum I think they had better be placed classified according to the inventions; but probably if there is to be a Museum of Patents these had better be placed together. There is a Patent Museum at South Kensington: there, of course, there would be nothing but patents.

10,669. I think you are probably aware that in the Patent Museum there are inventions of every kind, patented and not patented, almost without classification of any kind?—I was not aware of that. Then it would appear to me to be totally useless for the object.

10,670. Would it not be sufficient if in a classified collection of machines, apparatus, and processes, you had a label attached distinguishing those which were patented?—Yes, I think so.

10,671. (*Chairman.*) Are there any other points upon which you would like to make additions to your evidence?—I think that a very desirable way of helping on science is to assist scientific societies. In the case of the Literary and Philosophical Society of Manchester the difficulty of obtaining funds was at one time such that there was great fear that it would be compelled to discontinue the publication of its memoirs. Even now it has to be conducted with the most rigid economy. For instance, Mr. Baxendell, F.R.A.S., one of the secretaries, who with his other duties in connexion with the society looks after its publications, receives only 50*l.* per annum. That is a very small sum for the work which he does; and the librarian, Mr. Bailey, an able naturalist, who undertakes the correspondence with the societies with regard to the interchange of publications, &c., receives nothing at all. Of course the society cannot afford any more. It has but 360*l.* a year from subscriptions. The only way it exists is this, that Manchester men in years gone by presented the building, so that rent has not to be paid.

10,672. What is the annual subscription?—Two guineas. That seems to be a proof that a scientific society in the provinces, at any rate, cannot be carried on efficiently without assistance further than that of local effort, because I never heard of the society having lost the confidence and respect of the community among which it is situated.

10,673. Would any addition to the subscription seriously interfere with its success?—That was the turning point, I may say, of the existence of the society, the raising of the subscription, which was originally only one guinea. It was said, "If you increase the subscription the members will fall off." But the counter argument was that the value returned to the members was equal to the two guineas. And I believe it was through adopting this principle that the society has continued to go on; for the members pay the two guineas, but I do not think they would pay more.

The witness withdrew.

Adjourned to Wednesday next, at 12 o'clock.

No. 6, Old Palace Yard, Westminister, Wednesday, 1st May 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

SIR WILLIAM THOMSON, F.R.S., further examined.

Sir W. Thomson, F.R.S.

1 May 1872.

10,674. (*Chairman.*) I believe when you appeared before the Commission as a witness on a former occasion you expressed a strong opinion in favour of the appointment of a council of science to assist and and advise the Government on scientific questions?—Yes.

10,675. We did not pursue the subject very far at that time, and perhaps on the present occasion you could favour us somewhat more in detail with your views upon the subject?—The main object of such a council would, in my opinion, be to advise the Government on all scientific questions which might come under the attention of the Government, and on all scientific works actually undertaken. With a vast amount of mechanical work which is necessarily undertaken by the Government, and which is continually in hand, questions involving scientific difficulties of a novel character frequently occur: questions requiring accurate knowledge of scientific truth hitherto undeveloped are occurring every day. In both respects the Government is at present insufficiently advised, and the result is undoubtedly that mechanical works are sometimes not done as well as they might be done, that great mistakes are sometimes made: and, again, a very serious and perhaps even a more serious evil of the present system, in which there is not sufficient scientific advice for the Government, is the undertaking of works which ought never to be undertaken.

10,676. Are you able to point out any instances which you have in your mind of mistakes which you think have occurred from the want of good advice on the part of the Government?—One great mistake undoubtedly was the construction of the "Captain," and I believe that a permanent scientific council advising the Government would have made it impossible to commit such a mistake. They would, in the very beginning, have relieved the Government from all that pressure of ignorant public opinion which the Government could not possibly, in the present state of things, withstand. In many scientific works at present undertaken by the Government there is very excellent advice of skilled scientific men, officers of the Royal Engineers; but mechanical works undertaken by the Government are not consistently carried out according to the advice of any one competent body or of competent individuals, and many works undertaken by the Government are undoubtedly left to haphazard as to whether the existing knowledge of the day in scientific matters shall be available to direct their construction, or as to whether completely new scientific questions may be misjudged in advance, and great national loss thereby incurred. I may mention as one instance of the very great want of good advice, which I believe is a serious loss, the stone of which the Houses of Parliament were built. I believe also, although I do not sufficiently know the details, that great expense was unnecessarily gone to in respect to the ventilation of the Houses of Parliament. A good business-like scientific council or advising council for scientific matters would enormously diminish the expenditure which is incurred at present upon such matters, and would relieve the Government of a kind of anxiety which ought not to be put upon it. The Government is found fault with when those things are ill done, and has been found

Sir W. Thomson, F.R.S.

1 May 1872.

fault with even in such matters as the "Captain," but I must say that Parliament has not provided hitherto any means by which the Government can safely undertake such things at all, and yet they are obliged to undertake them. I may mention a piece of scientific work which at present is being done in a most admirable manner, under the Admiralty, namely, Mr. Froude's investigations on the dynamical conditions affecting the stability of ships. Circumstances have worked so that a man of first-rate accuracy and inventiveness and scientific knowledge has been permitted to do such work for the Government; but all this that is now being done and all the great benefits which undoubtedly will result from it might have been secured 10 years ago, and would have been secured 10 years ago, if there had been such a scientific council as I think ought to be constituted.

10,677. Do you think that a single body would be better than a number of small committees for advising the Government on the great variety of questions which from time to time would be likely to arise?—Yes, certainly.

10,678. The questions which might be referred to such a council would differ very much from one another, and extend over a wide range, would they not?—Yes, but there would be a unity of design and action, with a multiplicity of knowledge and skill at command, secured by a single council, and those conditions cannot, in my opinion, be secured at all by occasional committees or committees working separately and independently of each other. I may mention, for instance, that two of the very highest scientific men in this country, the Astronomer Royal and Professor Miller of Cambridge, have had in charge the National Standards of weights and lengths, but through no fault in them, but through the extreme difficulty of getting proper arrangements made under our present want of system, it seems that the work is not and cannot be carried on effectively. We have even to go to Paris to get French scientific men to do this work for us. At the same time the Government actually are in some strange want of good advice as it seems to me (I say it with some degree of diffidence, but it seems to illustrate the subject in hand very much), for they have referred the conservancy and the comparisons of the National Standards to the Harbour Department of the Board of Trade. No doubt the connexion is that weights and measures are wanted for the purposes of trade, then why not let the conservancy of weights and measures be under the Board of Trade? And why the Harbour Department should be chosen for that purpose of course I cannot imagine. The conservancy of weights and measures is a subject involving questions of the most extreme scientific nicety. Faraday made statements showing how completely unknown at present are the properties of matter upon which we depend for a permanent standard of length. One of the very first objects that should be undertaken in connexion with the conservancy of the standards of weight and length is secular experiments, or the dimensions of metals and solids, and solids of other classes under various conditions of stress, temperature, and atmosphere. Those would involve scientific experiments of an extremely difficult character, and also operations extending from year to year. There ought to be just now a set of experimental specimens of solids laid up which should be examined every year, or every 10 years, or every 50 years, or every 100 years, the times when observations are to be made from age to age being regulated by the experience of the previous observations. It would be necessary to begin observing every month, then when constancy is attained within the degrees of observable minuteness to observe every year, then every 10 years, then perhaps every 50 years, and then it might be sufficient to look at them every 500 years, and examine whether this copper standard and that brass standard have retained precisely the same length. This would not be a very difficult or expensive thing to institute in such a way as eventually to obtain good results, but it would be an operation of a secular character, which could only be carried out by the Government.

10,679. Would you put such experiments under the charge of this proposed council?—Yes; but to take a more immediately practical view as to weights and measures, it is absolutely necessary that the most precise methods of measuring that can be practised at the present day should be used for comparisons, in order to be able to give out accurate copies of the prototype standards, and those operations should be made in such a way as to involve the minimum of risk to the constancy of the prototypes that are used. Without going as far as 50, or 100, or 1,000 years, we must consider how to obtain the necessary accuracy for trigonometrical surveys and for the finer scientific measurements of the day, as well as for the purpose of trade accuracy according to the standards both of mass and of length. I believe that very insufficient precautions are taken to secure the constancy of the standards of weight. It is necessary that they should be kept in such a way and used in such a way as that no friction except the very minimum that is required to place them in the balance should ever be brought to bear upon them. I fear that we are at present in a very unsatisfactory state in these matters, and that in point of fact we have not preserved with sufficient care the standards which were actually compared by Professor Miller with the standards from various places on the continent of Europe, but it is impossible that the Government, with its multifarious duties and its great political preoccupation can attend to such matters, or even be cognizant of them. A scientific council would relieve the Government of all responsibility in such matters, and would be responsible itself in a general way for all its proceedings to a political chief and to Parliament. We have no security at present that the weights and standards are under scientific surveillance.

10,680. Would not you consider that whatever department of the Government it is under, it is responsible for putting it under the charge of a competent person?—In the same sense that they were responsible for sending the "Captain" to sea. They have no means of knowing, either on the one case or on the other, either what is wanted or how to carry it out.

10,681. There are some other objects, I believe, for which you consider that the establishment of such a council would be desirable? The immediate utility of the work is undoubtedly a very important object, and perhaps may be considered to be the first duty of the Government; but yet there is another duty which, although we cannot call it the first duty, is certainly not an inferior duty, and that is, to promote the honour of this country. There can be no doubt but that the inhabitants of this country do get benefit from the feeling of satisfaction that naturally results from any great scientific discoveries or great advances in science made by their own countrymen, and especially by the assistance of their own Government. The Royal Observatory at Greenwich is an honour and a glory to this country, and I am quite sure that the money paid for it is very well spent, in the satisfaction that the country feels in the honour of having one of the greatest and best, if not *the* greatest and best, of scientific astronomical observatories in the world. This country undoubtedly has a great permanent possession in the name of Newton and in the name of Faraday. The promotion of scientific research in a regular way cannot make Newtons and Faradays, but it can obtain great scientific results by systematic business-like action, carried out through well instructed and able men. It seems to me to be a duty of the Government to make the national honour in scientific investigation a subject of its solicitude and an occasion (with due safeguards against abuse) for spending the public money. This is not at all a new doctrine; the Government have very amply showed themselves sensible of their duty in this respect. Our Government have not always been restrained by the immediate utilitarian aspect of any question of the advancement of science that has been submitted to them. The sum of money voted for the observation of the transit of Venus is not for

Sir W. Thomson, F.R.S.

1 May 1872.

any immediate utilitarian object whatever, nor, I believe, for any utilitarian object, if the utilitarian object is to make that which is to help on the mechanical operations of the country. The improvement in astronomy for navigation will not be in the slightest degree promoted, I believe I may safely say, by that expenditure of money, yet it is an expenditure of money that will be acquiesced in and approved of by the whole country. I think I may say the same thing of the money that has been spent in the observations of the solar eclipses. The whole subject of solar physics has become one more and more minute, and extended, and continuous investigation. Through the great discovery of M. Janssen, and of your secretary Mr. Lockyer, the observations of the solar prominences can be carried on continuously. M. Janssen's discovery of the possibility was made in connexion with a solar eclipse: he found that he was able to continue, after the eclipse, observing the phenomena which had been seen during the eclipse; and Mr. Lockyer had, by a train of independent reasoning, some time earlier found that the thing could probably be done in that way, and prepared an instrument for the purpose of doing it. We have now the method fully given to us, partly through the expenditure of public money on eclipses, and partly through the expenditure of money, I believe from the Royal Society's Grant Fund, on instruments. Now it becomes an object of very great importance to use the means of investigation thus created, but resources are wanting for it. At present it is altogether in the hands of a very limited number of amateurs in the whole world, and most or all of those men are obliged to work hard in some other direction to support themselves. I say that it should be an object of national honour to promote such investigations, whatever the expenditure of money, and in whatever way it may be judged necessary. I merely mention that as one instance. Many other investigations which would bring in results of immediate interest to the whole country might be mentioned. The observation of terrestial magnetism, and of its connexion with solar spots is a subject which has excited very great interest, and which, taken in connexion again with submarine telegraphy and earth currents, forms a large field of investigation, but investigators are wanted for carrying it out on scientific principles in such a way as to make sure of getting good results.

10,682. Then it would be, of course, the duty of this council to point out to the Government the objects for which, in their opinion, the aid of the Government could be properly bestowed?—Yes.

10,683. Will you proceed to give us further your views as to the duties of this council?—To promote the efficiency of local laboratories, whether of chemistry or of physics, to promote their efficiency in respect to the discovery of new truths and the extending of science. At present there is a strong stimulus for local chemical laboratories in commercial analysis and various questions involving commercial interests, for which the work is paid at a remunerative rate. In this way there are many able chemists through the country supported by commercial chemical work. Those men, being generally very high scientific men, add to their commercial work scientific investigation; but many of them find it impossible to do so, and the tendency, I believe, is with all to become more and more absorbed in commercial work; not because they have a distaste or ever acquire a distaste for scientific investigation, and a desire rather for merely commercial and paying work, but because duties of that kind once gone into become absorbing. If a man begins to take commercial work to live upon he must end by giving himself up to it, or else he fails in his duty to his employer; and on this account commercial work is very apt to absorb the whole of the energies of the best chemists through the country; and that it has not done so is due in some respect to the very slight degree of Government assistance, and the assistance in national institutions of other kinds, which scientific research at present has. But it is of the greatest consequence that there should be a definite and secured position for chemists who devote themselves to scientific investigation. Without instituting chemical laboratories of purely scientific investigation in the country, very great good, in my opinion, might be done under the advice of such a council as this proposed council in giving moderate grants and endowments to employ scholars, able young men who have proved themselves capable, under the chiefs of the local laboratories, in carrying through the manipulations of scientific research. In physical laboratories, on the other hand, the object is almost purely the extension of science; and there is no department in physical laboratories at present which is self-paying on commercial principles. The physical laboratories have grown up, as I stated in my former evidence, altogether in connexion with the teaching of natural philosophy. As I pointed out, all our work is necessarily on a very insecure foundation, when it has any foundation at all, as far as the investigation of new truth in science is concerned. On the other hand, almost all that can be attempted at present in most physical laboratories is a practical course, in which the pupils will be taught weighings and measurements and specific gravities, and comparisons of standards and modes of measuring the strength of materials, the methods of measuring specific heats, the method and the practice of the method of measuring electric resistances of wires, and the electric resistance of insulating materials. There is a demand for knowledge and skill of this kind for young men going into engineering and telegraphy. No physical laboratory in this country can, unless as a matter of chance, do more than give practical instruction on the subjects which I have enumerated, and of course a few others of a similar character. It is merely an exception when it is possible either for the director or professor to undertake himself a scientific investigation, or to find a pupil who has both capacity and time to carry through a scientific investigation. I find myself the great benefit that very small endowments can produce in this way. Very small sums of money have sufficed to give the means to induce young men of capacity to devote themselves to experimental research, and to do so with really good effect. One case I may mention has resulted in a communication to the Royal Society of London, which has been accepted by the Council for the Transactions, and is now actually printed in the Transactions; namely, an investigation of the specific inductive capacity of dielectrics.

10,684. Was that investigation aided by a grant from the Government?—No, by a small endowment from a private source. Another investigation similarly produced through a small endowment, and capacity previously proved on the part of the individual has resulted in a complete investigation, the result of which will be communicated to the Royal Society in a short time. Again, an investigation on the conducting power of water and other liquids for heat is being undertaken in the physical laboratory of the University of Glasgow, but it has been carried out under very great difficulties, and hitherto with very great delay from the want of hands and want of means. Every physical laboratory in the country should have ample means for conducting such investigations. And I think that the endowment of physical laboratories, instituted in connexion with teaching institutions, and at present carried on for the purposes of teaching, might with great advantage be made under the advice of the proposed council an endowment for the purpose of scientific investigation. The subject of scientific instruction is not of course altogether detached. The same council might advise with regard to endowments which they considered suitable or necessary for scientific teaching; but I speak just now of endowments for the one purpose of promoting the augmentation of science.

10,685. I think, when speaking of chemical laboratories, you referred to some that were not connected with teaching institutions?—Yes, commercial laboratories.

Sir W. Thomson, F.R.S.

1 May 1872.

10,686. Are not physical laboratories, as far as you are aware, entirely connected with teaching institutions?—Yes.

10,687. What you propose is that assistance should be equally given in the one case as in the other, leaving it to the council on their responsibility to recommend what cases are proper for assistance?—Yes. The council might, for instance, find that a laboratory under a highly scientific chemist, hitherto engaged solely in commercial analysis, has capacity for scientific investigation, and they might find it advisable to give assistance in some form, in order that scientific investigation might be carried on in such laboratories.

10,688. Have several such laboratories been established as private adventures, so to call them?—Yes.

10,689. Would not there be considerable difficulty in the Government giving aid in cases of that kind?—Yes, I do not contemplate that a case of that kind could be dealt with in the way of endowment at all. The Royal Society's grant of 1,000*l.* a year (under the management of this council, as it would be if created) would contain, if augmented sufficiently for the increased requirements, the means of meeting such a want as I now speak of. When a chemist, having a commercial laboratory, or an amateur working in his own house, or anyone—professor, assistant, or student—connected with a teaching institution, shows that he has a scientific investigation in prospect, which he could make if he had the means allowed him, every such application for means might be referred to the council, and if a favourable judgment is arrived at, a grant should be made out of their available funds. Another object of the council would be to advise the Minister of Science in all applications for the expenditure of money to promote scientific investigations. Applications are frequently made to the Government of a singular character which could not be classed; some of those applications may be thoroughly deserving of support, and others may be of a most frivolous character. All such applications should be referred to one responsible council. At present the Government must be very much annoyed by occasional applications, and I have no doubt that the want of a permanent responsible and trustworthy adviser or body of advisers to whom all such applications can be confidently referred must be seriously felt. I may mention as an instance of applications of that kind, the applications made by the British Association for funds for the late and previous solar eclipses. The testimony of the Royal Society and the British Association to the importance of the object was no doubt in this case accepted immediately by the Government as a sufficient certificate that the object was a suitable one for the expenditure of public money. But there are many other applications even by the British Association itself which the Government feel must be referred to some competent adviser.* Then there are many applications made altogether by private individuals for assistance in some department of scientific investigation; those would naturally fall to be all summarily rejected at present, but it would be advisable that they should be handed over to a council of responsible advisers, who would take each case on its own merit.

10,690. Would you be so good as to inform us whether you have formed any opinions as to the best system of appointing such a council?—The council ought to represent the different branches of science, and the practical applications of science. Pure mathematics ought to be represented in the council; mixed or applied mathematics, according to the old-fashioned nomenclature as generally understood, ought also to be represented; chemistry cannot be shut out; physics must of course be represented and ought to be represented separately; astronomy, both what was formerly called physical astronomy, and, of course, the new science of astronomical physics, ought to be represented. I do not believe that astronomy could be properly represented under one head; astronomical physics must, in my opinion, be separately represented. Geology should be separately represented, and also the various branches of natural history; physiology also, and medical practice in general should be represented. I have spoken of applied mathematics, I meant rather mathematical dynamics than applications to art and mechanical operations. Then practical applications should be represented, mechanics and mechanical engineering, then again civil engineering and geodesy, mining engineering, statistical inquiries, and the scientific branches of Her Majesty's service ought to be thoroughly represented. Engineer and artillery officers, and the navy should be represented both in its navigation department and in the department of seamanship, and the department of gunnery. The mercantile interests of the country and the agriculture of the country ought certainly to be represented. The Universities ought to be represented amply; the English Universities, the Scotch Universities, and the Irish Universities. Also practical telegraphy, which is a very distinct branch of engineering, civil engineering or mechanical engineering would not sufficiently represent it.

10,691. Would you leave the selection of each appointment to the Government of the day, or would you allow scientific societies or other bodies to recommend, or would you propose that the Government should be obliged to consult such bodies?—I would prefer that the Minister of Science should have the appointment.

10,692. You assume that there would be a minister of science who should have charge of all those branches of inquiry?—Yes, he would naturally be influenced by all valuable testimony, both from the established bodies and from individuals, and having the whole responsibility, the possibility of making appointments on political grounds would, I think, be done away with.

10,693. In most branches of science, I presume, you would only have a single representative?—Yes, I think it would be desirable to have each branch named, and a single representative for that branch. The number of branches I could not exactly fix, even by suggestion, just now, it might be done somewhat approximately as my previous answers have indicated.

10,694. Would not there be a danger that when the Government consulted this council on any subject it would practically amount to little more than obtaining the opinion of the individual representative of the particular branch of science on which they wished to obtain an opinion; for example, a physiologist would not be of much use on matters connected with the instance you have brought before us, namely, the construction of the "Captain:" there might, perhaps, not be more than one or two members of the council who would be able to give an opinion upon that point?—Precisely so; but every question ought, in my opinion, to be submitted to the whole council, so that the whole council would be cognizant of the grounds upon which the decision is given. A single individual may be called upon to calculate the dynamics of such a problem as the "Captain," but unless he can explain the grounds of his representation to the satisfaction of a body possessing the degree of intelligence which this council would possess, I should consider that he had not sufficiently solved the question.

10,695. Do you think that his being able to satisfy his colleagues, even if most of them were not conversant with the particular subject of inquiry, would be a guarantee that the advice was good?—A very good guarantee; and one of the best guarantees, that every scientific man feels that he knows a subject is, to try to teach it. He thinks he knows it, and he begins to try to teach it, and he finds that there is a screw loose in his supposed knowledge. So if a man has a difficult question submitted to him by the Government off-hand, he takes a certain view, he is quite sure of it and he gives the advice, and the Government acts upon it. I believe that is very often done just now. At present

---

* As, for example, that for assistance to the Tidal Investigation. *See* Appendix IX.

Sir W. Thomson, F.R.S.

1 May 1872.

he could not give reasons because the executive minister would not have time to read them, but if he has to give reasons to a competent body, who have time to devote to the subject, he will have to work the thing out in his own mind in a way that even a most conscientious man may not do if he is simply asked for an opinion.

10,696. Besides the establishment of such a council, are you of opinion that any national institutions supported by the Government are required for the advancement of science?—I think that there ought to be institutions for pure research supported by the Government, and not connected with the Universities. The only suitable place at present for such institutions would be London, or the neighbourhood of London; in that situation, I believe, very great things could be done by institutions for pure research, at which work of a very great immediate money value would be produced at an extremely moderate cost, and I believe that discoveries redounding to the honour, and credit, and pleasure of this country would infallibly be made.

10,697. Are you able to give any idea as to how many such institutions would be required?—There should be five. One at present exists, namely, the Royal Observatory at Greenwich. Another in my opinion is very much wanted, an observatory for astronomical physics, then again a physical laboratory, and a laboratory for chemical research, and a physiological laboratory are necessary. In respect of such institutions, I believe, we might with great advantage obtain information, with a view to following example, in Paris. The strong feeling of the necessity to promote scientific research which was evinced shortly after the recent sad disasters which came upon France, illustrates very strongly the national value of such institutions. In the depths of their misfortunes, one of the first strong feelings shown by the most intelligent part of the French nation was the want of rigorous and accurate scientific research. Competitive examinations seemed in France to have swallowed up scientific energy, and there was a strong feeling of the insufficiency of the national institutions for promoting the advancement of science. This feeling arose, I believe, very much in connexion with the distinct consciousness of weakness in the use of the physical powers for warlike purposes, but, independently of that unhappily utilitarian object, I believe that the very leading of France to take an interest in rigorous and accurate scientific work will have an enormously beneficial influence in moderating and checking those features of national character which had so much to do with the bringing on of the war and with the disasters which they suffered, and with the present sad political condition of the country. When nations begin to feel that it is a national glory to outstrip one another or vie with one another in science, they will be less inclined to look upon it as a national glory to beat one another in war.

10,698. You would not propose that more than one such institution should be established of each description?—Not at present. I think that such an institution as a physical laboratory for experimental research could not be carried on successfully, except in connexion with teaching bodies, in any other place than London, at all events successfully and in all respects economically. I may perhaps limit the answer as to the number of such institutions, in respect to the observatories, that it might be necessary to have several observatories for astronomical physics in this country, if it were only to secure observations of interesting conjunctures, notwithstanding the varieties of the weather, that there may be in different parts of the country; and, again, observatories for astronomical physics ought most certainly to be founded in other parts of the British dominions than England, Ireland, and Scotland; in other latitudes and on the other side of the world.

10,699. Would such observatories be expensive institutions to establish and to maintain subsequently?—Yes, very expensive.

10,700. More so than the present observatory at Greenwich?—I do not know what the expenditure may be upon that observatory, but I should think that such an expenditure as that would do very great things indeed in experimental research, or in observations of any of the other kinds to which I have referred.

10,701. If they were established in several parts of the British dominions, the Government would have to incur a considerable outlay, would they not, in establishing them?—Yes, a considerable outlay. When I say great expense and considerable outlay, I mean that the expense would undoubtedly not be small, and the outlay would be worthy of consideration, but that the expense of maintaining such institutions and the first outlay in establishing them would be great in comparison with the value of the result I certainly do not for one moment imagine. I believe, on the contrary, that the results would be very great indeed, and would be very cheaply got for the money that must be spent upon them. The whole expense of maintaining this scientific council and of endowing physical observatories or laboratories to the large extent which is required in perpetuity would have been saved by the preventing of one such disaster as the "Captain," which would undoubtedly have been avoided if the council had existed.

10,702. Could you state what sum would be required for the establishment of such a physical laboratory as you propose under the Government; I mean the cost of the original building, and the cost of supplying the apparatus?—It would be very difficult for me to give an estimate on such a subject. My own laboratory is a part of a great building, and it is impossible to separate the expense of it from the expense from the rest of the building; 10,000*l.* undoubtedly would do a great deal. I would not like, however, to be absolutely limited to such an estimate as that. I should consider that for the building 10,000*l.* ought to do a great deal, decidedly, but the expense, besides, of supplying instruments, can scarcely be estimated beforehand. Several thousand pounds, to begin with, would be required for instruments. The best way really would be an endowment for instruments, and special application to the council for instruments which may be required from time to time; but I should say, to make a beginning, a couple of thousand pounds would go a great way towards supplying the instruments and machinery. It would not be advisable to allot more than such a sum as that for the first year or two to such an institution, and then gradually, by a process of natural selection, you might find out what instruments are required, and spend the necessary money in procuring them.

10,703. Would such a physical laboratory differ in any essential respects from a physical laboratory attached to a University?—Yes; it would be adapted solely for research, with no provision for pupils except what may be called apprentices, or pupils for research; no provision for teaching the mere elements of manipulation, but provision for researches directly adapted to increase knowledge, and for making pattern researches for the sake of training research pupils who had already gained experience and proved ability in institutions of instruction.

10,704. Would you leave the researches to be carried on at such a laboratory mainly to the discretion of the person who had charge of it, or would you place it in any degree under the control of the council of which you have been speaking?—I would leave it to the discretion of the person who has charge of it, with the understanding that the council is entitled to submit researches to him and to require his co-operation, because the requisitions of such a council, we must assume, would not be unreasonable.

10,705. And that the Government should also be able to command investigation on the advice of the council?—Yes.

10,706. (*Dr. Sharpey.*) Of course the director would report?—Yes, the director would report on everything, both researches undertaken at his own investigation, and investigations undertaken for the council, or for the Government.

10,707. And your view of what should be done in

Sir W. Thomson, F.R.S.

1 May 1872.

the chemical and physiological laboratories would, I presume, be something of the same nature?—Yes, something of the same kind, *mutatis mutandis*.

10,708. Are you able to express any opinion as to whether they would be more or less costly than the physical laboratories?—I am not able to express an opinion upon that, I should think it would be something of the same kind in point of first outlay.

10,709. (*Professor Smith.*) With respect to the apparatus, and the annual supply of apparatus, it is probable, is it not, that the physical laboratories would be the most costly?—Yes, the most costly in apparatus.

10,710. (*Dr. Sharpey.*) Some very fine instruments of a costly kind are now required in physiological inquiries, and large pieces of apparatus are sometimes employed, such as the respiration apparatus at Munich, which was put up on the recommendation of Professor Pettenkofer?—Yes, it would be, in my opinion, necessary not to limit to a fixed endowment the expenditure of any one of those institutions, but to let it be determined (if I may use the expression once more) by natural selection; applications for money to be made to the council to be duly weighed, and the council to apply to the Treasury. That would be much more economical than giving a fixed sum, which, being to be spent, might be spent without due regard to economy, or which, on the other hand, might prove to be insufficient for valuable researches, causing the institution thereby to be crippled and to lose efficiency.

10,711. (*Chairman.*) You would not think it indispensable, would you, that such institutions, if the Government thought fit to establish them, should be in the heart of London, or in any very central situation?—No. It would be much better that they should be in the country in positions conveniently accessible to London. For a physical laboratory quietness of the ground is of immense importance. It would be impossible to make a great deal of the most important scientific investigations in a physical laboratory within 100 yards of any of the great thoroughfares of London, and a much greater distance than 100 yards is quite necessary for many such investigations.

10,712. You would not institute any regular provision for teaching in those laboratories?—No.

10,713. But you would allow young men or students who wished to carry out original research to avail themselves of them under the direction of the persons who were in charge of them?—Yes, under the direction, and to some degree under the instruction of the persons in charge; but the instruction should be limited to methods for advancing science. The director of such an institution must not be occupied with lecturing in any other institution, or with lecturing at all. He ought, indeed, to be prohibited from lecturing, except one or two occasional lectures in the course of a year.

10,714. You think that the object for which you recommend the establishment of those laboratories could not be accomplished by any other means—not by investigations carried on in other laboratories in the country?—Certainly not by any other means.

10,715. In addition to those institutions which you have recommended you consider, do you not, that it would be advisable that the Government should undertake secular observations of the tides?—Yes, certainly, secular observations of the tides with accurate self-registering tide gauges, with the triple object of investigating the science of the tides, of perfecting our knowledge of the actual phenomena of the tides, both in respect to navigation and as a branch of natural history, and thirdly with a view to ascertaining the changes of the sea level from century to century.

10,716. Is anything of the kind done at present?—There are several tide gauges, some of which have been carried on with great care, others with not sufficient care, and none with any security of permanence.

10,717. (*Dr. Sharpey.*) Did not the British Association within the last two or three years propose the establishment of beach marks at various points on the coast?—Yes.

10,718. Was anything done in consequence?—Not so far as I know.

10,719. Was not it in connexion with the Ordnance Survey of Great Britain?—I do not know the particulars of that recommendation, but I do know that no sufficient steps have been taken to ascertain whether the sea level is changing relatively to the land in any part of this country. Colonel Walker of the Trigonometrical Survey of India has taken up the question very seriously. This led him to investigations of the tides, and he finds that to determine whether certain points of the coast are changing in their level relatively to the sea or not, requires continuous observation, for a considerable period of time, of the height of the water at each instant. He has accordingly taken up the subject of the tides, and has adopted the method recommended by a recent British Association committee on tides, and has employed an officer on his staff, in the first place to learn thoroughly the practice of that method, and in the second place to go out to India with printed forms and the other appliances that are necessary for putting the calculations and reductions in practice. The same practice as that which Colonel Walker is now introducing in India ought, in my opinion, to be established permanently in this country for tidal observations, and in other parts of the British dominions, and indeed in other parts of the the world; because it is of no consequence to us whether a point in the coast belongs to France, or to England, or to the United States, in a scientific question of this kind. If we get the observations we cannot class them under nations, but naturally we should wish to reduce them all together. The making of the observations would naturally fall upon the Governments of the different localities, but the reducing of them is not a national matter at all.

10,720. (*Chairman.*) Would you think a large number of stations requisite for the observations of the tides to which you have alluded?—Yes, a large number. The phenomena of the tides are of great complexity, but not of baffling complexity, provided that we make the observations at a sufficiently great number of points.

10,721. Would the duties attached to such observations take up the whole time of the persons who had charge of them?—By no means. They could undertake other duties. A tide gauge may be put under the hands of a careful harbour master or officer of the coastguard service at any station, but it must be under inspection to secure accuracy. The most careful and scrupulous of such men cannot make sure that the instrument is giving accurate results; and they cannot, except under instruction and occasional inspection, give out recorded curves, that they can be quite sure of being accurate in all points of scientific nicety; but the inspection that is required to secure accurate results would be a very simple and moderate matter.

10,722. Such observations as you recommend would not be a very costly undertaking?—Not very. The first cost of the tide gauge, in setting it up, would be the chief expense.

10,723. No expensive building, or anything of that kind, would be required?—No; the slight additional work that it would give to a man already employed on the post would be a very small expense. The inspection would be a considerable expense relatively to one or two stations; but if there were a large number of stations, the inspection would be very small for each. One competent man could inspect all the tide gauges for this country and Ireland, and perhaps for the whole world.

10,724. How many stations should you say would be sufficient for the United Kingdom?—For the scientific inquiry, I should say that six or eight stations well chosen would probably be sufficient, but it would be desirable that each harbour, for its own sake, should have a good tide gauge.

10,725. (*Professor Smith.*) I think we have inferred that, in your view, the council of science that you pro-

Sir W. Thomson, F.R.S.

1 May 1872.

pose would be a somewhat numerous body?—Yes, necessarily so.

10,726. And I presume that it would be your view that its members should be remunerated for their services?—Yes; necessarily it would be a body that would have a great deal of hard work to do, and it would be a body that would be worse than useless if it had not hard work given to it.

10,727. Then your idea would be that this council of science would have to meet or would have to work pretty permanently during the whole of the year?—Permanently during the whole of the year, with suitable official vacation.

10,728. You would not compare it, would you, to such a body as the medical council, for instance?—By no means.

10,729. But rather to such a body, in this respect, as the Indian Council, that would meet permanently?—Yes, it might meet two days a week, the whole session: certainly to meet at frequent regular intervals.

10,730. Then, in fact, the duties of the council would occupy a very considerable part of the time of the members of it?—A very considerable part.

10,731. Then it would be necessary, therefore, that their remuneration should be considerable?—Yes; I have no doubt that the way in which the thing would work would be, that many members of the council would have their whole time occupied by it, but that there might be some *ex-officio* members of the council who could hold duties in some other institution; for instance, the director of the physical laboratory should be *ex-officio* a member of the council. But it would be quite impossible for him to take any of the ordinary council work upon his hands, or to attend the meetings regularly. It might only be on rare occasions that he could find time to attend the meetings. If the thing were to begin by requiring that the director of the physical laboratory should attend the meetings two or three times a week, the physical laboratory is ruined from the beginning, and it would do no good if the man's time is to be frittered away by attending meetings.

10,732. I presume that you would also think it necessary that this council, in order to give the best advice to the Government, should occasionally take advice themselves. You could not be sure, could you, of always having upon the council the very best authority upon the particular scientific question that might arise?—The very best is a hard word, but something as good as the very best, I think, ought always to be on the council.

10,733. Then you do not think that there often would be any necessity for their going outside their own body?—No; I have no doubt that the members of the council would be intimately acquainted with other scientific men, and would give and take all that could be given and taken in the way of knowledge, and questions proposed to the council might be discussed between scientific men not on the council and members of the council, but the council must be strong enough of itself never to put officially a question anywhere else.

10,734. I gather from the functions which you would propose to assign to the council, that you would relieve such a body as the Royal Society of the duty of administering the present Government grant fund?—Yes, certainly, I would transfer that to the council.

10,735. Do you think that the council which you propose would be a body better fitted for such a purpose than the body that at present administers it?—Yes, I think very much better fitted from its organisation; not better fitted from its constituents, because the council of the Royal Society does contain the very highest power of the country, and they must always and will always, we may hope, contain the highest scientific power of the country, but its organisation renders it impossible that it can be so good an administrator of this fund as the proposed scientific council would be.

10,736. I notice that you have spoken of the great importance of giving a definite and secured position to scientific workers, to persons engaged in the prosecution of scientific research?—I think that that is of vital consequence to this country. That men should be enabled to live on scientific research is a matter of most immediate consequence to the honour and welfare of this country. At present a man cannot live on scientific research. If he aspires to devote himself to it, he must cast about for a means of supporting himself, and the only generally accepted possibility of being able to support himself is by teaching, and to secure even a very small income, barely sufficient to live upon, by teaching, involves the expenditure of almost his whole time upon it in most situations, so that at present it is really only in intervals of hard work in professions that men, not of independent means, in this country can apply themselves at all to scientific research. Then the great amount of popular lecturing, and popular teaching, and popular writing that is, happily I say, being demanded has a very unhappy effect at present in absorbing such an immense amount, as it does, of the valuable scientific energy of the country. I have heard it likened to an army in which the general is employed in teaching the goose step to recruits.

10,737. So far as the younger men are concerned, I think you suggested a way in which the difficuly might be met by giving them, what I may call, for the moment, scholarships, or fellowships, to enable them to continue their pursuit of scientific inquiry, but have you considered the question of how you would deal with older men; in other words, how, after you have induced young men to enter upon a career of scientific inquiry, you could afterwards provide them with a competency?—By demanding scientific investigation and paying for it.

10,738. You would hardly, I presume, apply the system of payment by results to scientific investigations?—No, anything of the kind must grow up naturally. It would never do just now to offer a certain number of salaries for scientific investigation, but the thing must be worked naturally. In the first place, if the proposed plan is carried out, the physical laboratory itself would be the natural promotion for young men who had shown competence in the work, for many of those young men will go into other professions, and to have held research-scholarships, and to have been put into a position to be able to do the work they imply for a few years of their lives will be to them a valuable education and a valuable certificate, and will allow a man to go into engineering at 28, perhaps, with more useful knowledge and experience than a man who has been in the profession from the time he was 18 or 19. It will have its value to a multitude of young men, if there is a multitude coming forward in the way of experimental research. The comparatively small number that prove high capacity for experimental research, could not be worse off than they are at present, at all events they would then have a chance of being promoted to being director of a physical laboratory, or first assistant, or second assistant. Of course, in the endowment of a physical laboratory, or a laboratory in any other department, there must be a chief and there must be several well paid assistants, and that would be the natural promotion for young men who have grown up in the laboratory, and I think it would afford an ample field for any number that could possibly come forward in that way. If the thing grows, and there is a demand for it all over the country, it would be pretty expensive, but that would be because the thing is wanted, because the nation wants it, and then the expense would not be considered too great. But a moderate beginning, such as that which is proposed, cannot in the nature of things bring forward a larger number of young men skilled in scientific work than will be provided for either in experimental inquiry itself or in practical science, such as engineering and telegraphy. It would be of the greatest value to engineers to have young men of real capacity in physical science, instead of merely young men who have gone through the office work and got a certain amount of formal instruction in drawing and in

Sir W. Thomson, F.R.S.

1 May 1872.

calculating, according to the Engineer's Pocket Book, and so on.

10,739. You do not think it quite impossible for places of scientific instruction to be so arranged that the duties implied by them should not be too onerous to prevent scientific research on the part of persons entering them; you do not think it impossible to combine scientific instruction and scientific research, but you think that the duties of the professorships in the country might be so arranged as to give time for scientific research on the part of the persons holding them?—Yes; and I think that great improvement is imperatively demanded there. I have been speaking of the proposed laboratories of research, but laboratories of instruction must be arranged so as to become also, to a great degree, laboratories of research; and one most necessary part of the arrangement will be to free the professors of a large part of the drudgery that they at present have, but at the same time to put them in such a position that they will work quite as hard as they do now, only that instead of doing drudgery, which can be done with equal excellence, or which perhaps may be better done by persons of a different calibre altogether, their time may be free for scientific research. I do not propose that their situations should be made sinecures, but that their time should be left free for scientific research, and scientific research should be exacted of them.

10,740. So that, in fact, it would render those places objects of ambition to men who felt a vocation for scientific research?—Certainly. In science a professor cannot be a good teacher unless he is also an investigator. At present many men are investigators as far it is possible in the circumstances in which they are placed; some, however, are absolutely prevented from making investigations, but the teaching is starved out in that way and becomes of a lower grade, and the whole system tends to fall into a method of preparing to pass competitive examinations, instead of teaching the truths of science and a general interest in science; indeed I have great apprehension regarding the growth of the system of competitive examination. There is nothing so inconvenient to an examiner as the augmentation of science; it introduces an unfair element into the examination. One man chances to have been taught by somebody who knew science, and another man has been taught to read it according to the books which will probably be set by the examiner. A competitive examination might be made exceedingly useful, not merely for the purpose of testing, but to promote good learning. To be so, it must be conducted at very frequent intervals (once a week or so) in immediate connexion with the teaching, and under the direction of the teacher.

10,741. Do you really think that the competitive examinations at the Universities at present do not exercise, to say the least, a stimulative effect upon scientific research?—I think not at all. To some degree, competitive examinations produce an elementary smattering of science I have no doubt whatever, but I cannot see that they produce much beneficial influence; and in the higher parts especially, they have, I fear, a very fatally injurious tendency in obstructing the progress of science; indeed no greater mistake can be made with reference to examinations than separating the examinations from the teaching. The teacher ought to be the examiner, and the teacher ought to be checked, if necessary, so that he may not pass off inferior teaching and stamp it with his own mark of examination, but the examiner ought to be to a great extent the teacher; see that the teaching is good and the teacher is good, and let him examine, and let him give evidence that his examination has been a valid examination.

10,742. You think, do you not, that especially the older and more richly endowed Universities might do something for the promotion of research on the part of their students?—I think so. At present the great difficulty in the University of Cambridge is the Senate House examination. The establishment of a physical laboratory in the University of Cambridge will, I believe, lead to a new state of things, but the great initial difficulty is the difficulty of having the ablest men among the undergraduates free enough from care to take a high place in the Senate House examination. If there were not that state of high pressure to secure a great number of marks upon the examination paper, young men well instructed in elementary mathematics and able to undertake the highest mathematics would make splendid experimenters, but if they have to risk their place in the Senate House they cannot be expected to do so, because their whole prospects in life sometimes depend upon that, as after they take their degree they must go into professions, and if the Senate House examination were moderate in comparison with what it is, so that an able man would not think it necessary to be first, or second, or third, in particular, but would be sure of taking a good place, he then might have three or four hours a day which he would employ in the physical laboratory, and undoubtedly he would, after he had taken his degree, be a much more able man of science and much better prepared to turn his science to good account than there is much chance of his being on the present system.

10,743. You have expressed an opinion that at those national laboratories of which you have proposed the establishment, opportunities should be given to persons not belonging to the staff of the laboratory to carry on research?—Yes, certainly, they ought to be open to volunteers, whether amateurs, or professors, or students, volunteers proving their competency and fulfilling certain conditions, and using economically and effectively the resources put at their disposal.

10,744. And you think that such a system as that could be worked without difficulty?—I have no doubt but that it could. I have the strongest reason to believe that it could, as I have had experience of a somewhat similar system on a very imperfect and small scale, and under circumstances much less advantageous.

10,745. Do you think there would be likely to be any demand on the part of the scientific public for such facilities?—Yes, I believe that there would be many applications, and I believe that the number of applications would grow.

10,746. And that it would be felt as as a boon by the scientific world?—Yes, I think that it would be felt as a very great boon.

10,747. (*Dr. Sharpey.*) Would you contemplate that a new department of the State should be constituted for directing the scientific work of the Government?—It would be quite necessary to have a Minister of Science; it is, indeed, I think, generally felt that a minister of science and scientific instruction is a necessity.

10,748. Not a minister of other instruction?—Specially of scientific instruction, and not under any national education board, but a minister of science and scientific instruction. The minister would necessarily be in Parliament and a political man, but it would be very rare that he could also be a scientific man, and perhaps not desirable that he should be a scientific man, but he must have able scientific advisers always at hand.

10,749. Could any such duties be well assigned to any existing department of the State?—I believe not.

10,750. Do you think that the functions which are proposed to be assigned to the scientific council would not interfere in any way with the existing scientific departments of the Government; for example, the Medical Department of the Privy Council, or some of the other Government scientific departments?—I think it would relieve the departments from pieces of scientific work at present given to them, because there is no other body to whom they can be given, and for which they are by their organisation and *personnel* almost necessarily ill fitted and insufficiently competent.

10,751. You would leave to these departments their administrative functions, but give them the advantage of consulting with the council upon higher questions of science on which they desired information?—Yes, certainly, every question of science that falls under the

Sir W. Thomson, F.R.S.

1 May 1872.

notice of any department of the Government would naturally be referred to the scientific council.

10,752. Would you propose that the first step towards the amendment of the scientific affairs of this country should be by the appointment of the council of science, or that the other practical measures you have indicated should be adopted in the first instance, such as the establishment of laboratories and the like?—I think the whole should be simultaneous. If the council were formed first no doubt the council might immediately begin to work effectively, and would do good, but if the council were formed first, and it were left to subsequent decision whether or not to make physical laboratories and other institutions of that kind, I think that there would be a great risk of some of the most important objects being lost. On the whole, however, I should say that the council should be first formed, but I think it should be formed with the idea that part of its duty and the first part of its duty shall be advising as to such institutions, and that it is not merely to be given as an instalment without the promise of any more.

10,753. (*Professor Huxley.*) A practical difficulty that has occurred to me, is whether it would be possible to secure the services of men of high scientific attainment upon the council of science, considering the demand which it would make upon their time. I apprehend that you contemplate the meeting of the scientific council twice a week, or, perhaps, even oftener, and in many cases the business of the council would take up a great deal of the time of the councillors; would not that be as bad as too much elementary lecturing, and perhaps rather worse?—I do not think that it would. It would be a large call upon time, but it would not be large in proportion to its being of distinctly scientific value. The business of the council, I presume, would be so well arranged that three or four hours would not be spent frequently in fruitless discussions, but there would be distinct questions for thorough accurate investigation. The mere business would not take up much time, but there would need to be one, or two, or several members, probably, who would have a general management of the whole business, and their time, I think, would be so much taken up that they could not devote themselves so much to experimental research, but I do not think that the majority of the members of the council would find that a meeting of that kind would fritter away their time, and, above all, consume their energy in the way that too much lecturing and too much examining does.

10,754. (*Sir J. Lubbock.*) I gather that you are in favour of a permanent council rather than of special committees for particular purposes?—Yes, certainly.

10,755. Supposing there were some question connected with astronomy, say an eclipse of the sun: do you consider that such a question as that would be better referred to a permanent council in which various branches of science would be represented, rather than to a body of 8 or 10 who might even be all of them chosen from the best astronomers of the day?—Yes, I should think it would be very much better referred to such a council.

10,756. As to the nature of the appointment, do you contemplate that the appointment of the members of the scientific council should be for life?—I think so. To have the work well done, I believe, it ought to be a life appointment, with a provision for retirement as in other offices of the Government.

10,757. Have you considered whether perhaps an appointment for say five years might be preferable?—I should not consider that that would promote the efficiency of the council.

10,758. Referring to some of your remarks with reference to the examinations at Cambridge, did I rightly understand you to imply that on the whole you consider the Oxford system of classes is better than the Cambridge system of places; is that the tendency of your evidence?—So far as the University examinations are concerned I think it would be better. I think the great thing of being senior wrangler is too much like the Oxford and Cambridge boat race, too much a sporting thing for science and the higher mental culture. I am afraid, however, that Oxford is not free from the epidemic or plague of too much examination, but I speak with diffidence as I do not know the system sufficiently. I have a great horror of fellowship examinations, years and years after a man has taken his degree. I think when a man has taken his degree he should be stamped, examined to the utmost, never to be examined again.

10,759. You spoke of the necessity for having a minister of science, do you conceive that it would be requisite to have a cabinet minister for education and a second cabinet minister for science, or would you contemplate that the minister for education should be the minister for science?—I do not wish absolutely to fix it beforehand; on the whole I think, however, that the title of minister of education would not suffice. If there is to be a minister, it must be a minister of science and education. There might be a minister of science and education, with a chief secretary or under minister for national and elementary education, and another for the advancement of science and for the higher scientific instruction. But naturally the minister of education must act for the masses, that must be his great duty, and however much he might wish to act for science, he has still a great duty to the masses. On the whole, I think that it would be preferable to have a distinct minister of science and scientific instruction. A minister of science and scientific instruction, as a subordinate to a chief minister of science and education, might probably be a very good arrangement.

10,760. Do you not think that the complete neglect of all science in our elementary schools has been a great misfortune, and has been due to the fact that those who have had the supreme control of those schools have no appreciation whatever of the national importance of science?—Yes, I do think so.

10,761. From that point of view it would be desirable, would it not, that there should be one minister who should be responsible for the science and also for the education, because otherwise there would be great danger of continuing the present vicious system of entirely ignoring science in our elementary training?—Yes, if it could be so arranged that the advancement of science and of higher scientific instruction does not suffer, then I should consider that the benefit which elementary education would receive from this association would be a strong reason for putting all under one minister of science and education.

10,762. No doubt there would be a chief secretary, or some official under some corresponding title to that, whose business it would be to consider the higher scientific subjects, while the management of the elementary schools of course would be under a different official; but at the same time your impression is, that so far as the head of the whole is concerned it would be desirable not to treat science and education as two different subjects altogether, but that they should be under one supreme head?—Yes; that might be desirable, but it must always be borne in mind that the minister of science has a large part of his duty quite distinct from education.

10,763. Of course there is a great practical difficulty in multiplying too much the number of cabinet ministers?—Yes. A very fair title for the head of the department might be minister of science, because, after all, education is a part of science, to take a sufficiently large view.

10,764. All instruction which is worth anything?—Yes. Science is knowledge, and the minister of science administers knowledge to the whole country.

10,765. (*Chairman.*) Have you not any fear that this proposed council might be too numerous to do much work; is not a large body, consisting of something like 50 members, that you would propose, rather too large for practically getting through much real work?—No, I think not, because the work is so multitudinous that it would necessarily divide itself into working committees; but general meetings of the whole council would in my opinion be of great value;

Sir W. Thomson, F.R.S.

1 May 1872.

and the fact of 50 men being all present would, I think, be in many cases that would be submitted to them in their ordinary work a great benefit.

10,766. You would think it essential that there should be sub-committees?—Yes, quite essential.

10,767. I think I understood you to say that you would recommend that the severity of the examinations in the Senate House at Cambridge should be somewhat reduced, and you contemplate that some of the best men would devote part of the time saved from preparation for examination to original research?—Yes.

10,768. But would not there be a fear that although a certain number of the best men would do that, the larger part would spend in idleness the time that they would save?—I scarcely think so. The examination cannot be said to be too severe for those who are content to pass with honours; but for those who strive to take a very high place the strain is very great, and it is such that it becomes the first duty of the candidate to get as high a place as he can. A man of honourable feeling makes it a point of honour to do all he can to get the highest place; but if he were put in a position in which he has done his duty when he has prepared himself as well as possible in science, and has gone into mathematics and dynamics, and so on, in a scientific spirit, without preparing himself to show in a certain time a great knowledge of the subject, then he will have obtained all the substantial benefits of the Cambridge course of reading, which are very substantial and valuable; and he will have a great deal of free time for experimental research. A man cannot with advantage read and digest pure mathematics or applied mathematics for a very great number of hours a day. There is ample time left for experimental research, along with the most thorough mathematical culture. I believe the men would be not merely not inferior mathematicians, but that they would be better mathematicians than they are, if they were relieved from the competitive examinations of the Senate House.

10,769. (*Professor Smith.*) But it would be impossible for the examiners to reduce the severity of the examination, for it really depends, does it not, upon the competition; so long as that examination is in this manner competitive, it must be mentally severe?—But suppose the first 30 were put in one class, then the able mathematician walks into the place without a thought of the examination, and his whole time is free for experimental research, but you cannot ticket those first 30 in order. Moreover, I say what is the value of the ticket in order of merit? It is of little or no value.

10,770. But, then, how would you give away fellowships? You would be obliged, would you not, to introduce a competition at the later stage, which is practically what we do at Oxford?—It is a great difficulty, but I believe it could be got over much less detrimentally than the Senate House examination at present gets over it. It is not often merely to earn a fellowship that the great strain is, because a fellowship very seldom depends upon a man being first, or second, or third. If he gets amongst the first 10 he is sure of a fellowship, but it is the honour of the thing, and it is really a point of honour more than merely the chance of getting a fellowship. The chance of getting a fellowship, the necessity of working for a fellowship makes it necessary to go in for the examination, and a young man when he goes in for the examination is not going to let himself be beaten if he can help it. If a man is obliged to go in for a boat race, he would rather kill himself than lose, but better not to oblige him to go in.

10,771. Do you think it would be possible to give away fellowships to any extent, not merely as is done at present with reference to attainments, but also with reference to the candidate having shown some aptitude for scientific research?—Certainly, that is one of the methods that I have in my mind; that aptitude for scientific research and success in science research should be the primary point. A good mathematician who has shown an aptitude for scientific research, and who has made some original investigations, ought thereby to earn a fellowship. He would earn it by a very much more valuable consideration than as at present in a mere schoolboy examination, getting number one instead of number two, or number two instead of number three.

10,772. And you think that in that way the Universities might do something for the promotion of scientific research?—I think they might do great things. It is a sad thing to see such splendid Universities as Oxford and Cambridge with such grand associations and such great power lost as they are.

10,773. Then in any scheme for University reform you would be disposed to recommend such a change as that, as being one very desirable in the interests of the Universities themselves?—Yes, certainly.

10,774. And in the interests of science?—Yes.

10,775. (*Chairman.*) The tribunal that would have to decide on the claims of any candidate for a fellowship, on the ground of his distinction in original research, would be constituted, I presume, of members of the University?—Yes, certainly.

10,776. At present might there be a difficulty in constituting satisfactorily such a tribunal?—No, I think not. The professors in either Oxford or Cambridge, I believe, would be the best tribunal that could possibly exist.

10,777. Would you take the power of appointing to fellowships from the colleges, and vest it in a council of professors or some such body?—I do not know that I would propose to take it away from the colleges; the question of patronage is very difficult. The colleges exercise patronage in such a thoroughly fair way that nothing could be more satisfactory in that respect. If, on the other hand, the colleges are called upon to take into account other considerations besides the distinct mark of each man in an examination, their task becomes more difficult. The absolute purity and freedom from every tendency to jobbing that is shown by the colleges, would, I believe, still continue; but their election would be made considerably more difficult. Yet even at present, I believe, the election would be extremely well made indeed in all the colleges at Cambridge if their duty were laid down for them as to appointing a man who had proved competent in the University examinations, and also had shown qualifications in certain other departments distinctly laid down. If they are simply left to elect a man that would be a pleasant addition to their number, then their duty takes altogether a different form, and one which would not be so beneficial in the interests of the college or the University.

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 3rd May 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., LL.D., F.R.S.

GEORGE GORE, Esq., F.R.S., examined.

G. Gore, Esq., F.R.S.

3 May 1872.

10,778. (*Chairman.*) I believe you have been for many years engaged in teaching the Sciences of Chemical Physics and Chemistry?—Yes, I have.

10,779. And in other occupations having a close relation to those subjects?—I have.

10,780. You have also been engaged in making original scientific researches?—I have.

10,781. The subject of the advancement of science has engaged much of your attention, has it not?—It has on frequent occasions.

10,782. Are there any measures that you can suggest to the Commission which you wish to see adopted in order more effectually to promote this object than is the case at present?—I propose that national laboratories should be established, in which abstract scientific investigation alone should be carried on. I propose that in those laboratories scientific investigators should be wholly employed upon abstract original investigation, and be paid for their labour and be supplied with the necessary means in their respective sciences, leaving each investigator to choose his special subjects of research.

10,783. How many of those laboratories would you consider essential or advisable?—That is a subject which I have not entered into.

10,784. But perhaps you could explain to the Commission rather more fully what should be the general character of those laboratories?—For making original scientific investigations in the subjects of chemical physics and chemistry. I speak only within the subjects with which I am familiar.

10,785. Do you refer, in this recommendation, to the establishment of a physical laboratory?—If you mean by a physical laboratory one in which the sciences of heat, light, electricity, and magnetism would be investigated, I should mean a physical laboratory.

10,786. And you think that that ought to be distinct from a laboratory for chemical physics and chemistry?—Yes, I think distinct from the laboratory for chemistry only.

10,787. I understand you to recommend that this should be a Government institution supported entirely by Government funds?—Yes, I do recommend that.

10,788. And under what conditions would you propose that persons engaged in scientific research should be allowed to make use of the laboratory?—I consider that they should be paid officials, whose sole occupation should be to make such researches as I have mentioned.

10,789. You mean that the persons employed in the laboratory should be also in the pay of the Government?—Yes, exactly; they should be wholly employed in making those researches at the expense of the State.

10,790. Do you propose that the laboratory should be at the service of any person who wished to engage in research?—Not at all; I do not mean that.

10,791. Then those officials would be persons employed by the Government in a certain sense to make discoveries?—Yes.

10,792. Do you think that that is practicable, that persons can be ordered to make discoveries, and will make them?—If you select persons of repute who had already made discoveries, they would be able to do so.

10,793. To what department of the Government would you entrust such a function as selecting discoverers?—I do not think that at present there is any department of the Government that is qualified to select such gentlemen. I think there ought to be a scientific department of the State, of which that should be one of its functions.

10,794. (*Sir J. P. Kay-Shuttleworth.*) Supposing that having found your Faraday, and put him into the State laboratory, and 12 years elapsed without any discovery being made by him, what would you do?—I should suppose that no such thing would happen. I do not think it at all likely that such a circumstance would occur. If a man of repute were placed there and an honest man, I have no doubt he would do his best to make important discoveries.

10,795. (*Dr. Sharpey.*) Would you prescribe a line of discovery for him?—I would prescribe the sciences within which he should make discoveries, but nothing beyond that, I think.

10,796. You would have no reference to the public wants at the moment?—Not at all; I think that it would be very desirable that they should not in any way be considered.

10,797. (*Sir J. P. Kay-Shuttleworth.*) Your proposal is that first there should be a laboratory with all the necessary apparatus for investigation?—Exactly so.

10,798. And then that there should be appointed in that laboratory, such a person as might be regarded by a scientific jury as most competent to make those investigations?—Yes.

10,799. And that he should be provided with the means of subsistence?—Yes, exactly.

10,800. And that the country should depend upon his character and qualifications for the result?—Exactly so.

10,801. (*Chairman.*) Do you think that such a laboratory ought to be on a very extensive scale?—Not very extensive, I should imagine.

10,802. Would it be of a different character from any chemical laboratory at present existing in this country?—No, much the same.

10,803. Could not such investigations be carried on in any existing institutions?—I think they could.

10,804. (*Sir J. P. Kay-Shuttleworth.*) Do you think it at all desirable to connect that function of research in any degree with the function of teaching, or would you separate the function of research from that of teaching?—I should entirely separate them in this instance.

10,805. (*Chairman.*) The existing chemical laboratories are chiefly connected, are they not, with teaching institutions?—Yes, they are.

10,806. And you would think it desirable to have a separate laboratory entirely occupied in promoting original research?—Exactly so.

10,807. (*Sir J. P. Kay-Shuttleworth.*) Can you point to any institution in Europe which you would regard as an example of the kind of laboratory which you desire to see established in England?—I do not think one exists, or at least, I am not aware of one.

10,808. Is the Royal Institution at all an approximation to the model of the institution which you would desire to see established, in which Sir Humphry Davy, Faraday, and others have made their researches?—That portion of the Royal Institution which is devoted to original research would be the sort of thing which I think should exist in this laboratory; but the other objects to which the Royal Institution is devoted I should think ought not to exist in this laboratory.

10,809. You think it a disadvantage, therefore, to Sir Humphry Davy and to Faraday to have had to give a certain number of lectures during the year on the more elementary portions of the sciences in which they were making investigations?—After they

G. Gore, Esq., F.R.S.

3 May 1872.

had attained a certain degree of repute I think it was rather a disadvantage to them. They would have made more discoveries had their time been more fully occupied with original research.

10,810. (*Chairman.*) If the Government were disposed to undertake the establishment of such a laboratory, would you have them found it upon the principle of promoting pure science, or would you think that they ought to have in view any practical results?—I think that the practical view should be especially and entirely avoided.

10,811. You think that it ought to be established solely with a view to promote science?—Solely with a view to promote pure abstract science, otherwise speculators would get hold of the results that were obtained and they would be used for individual purposes. I consider that that would be the only way to give it a really national character, and it would be the only way in which the results which would be obtained would be truly national.

10,812. Can you give us any reasons why you consider it the duty of the Government to promote science?—Because nearly the whole of the benefits derived from original research are of a national character, and scarcely any of the benefits derived from it go to the man who does the labour of the investigation; and another reason is that abstract scientific research has already proved itself an unlimited source of new industries and of improvements in trades and manufactures; those are the most important reasons, I think.

10,813. Besides the establishment of your proposed laboratories, are there any other measures that you would wish to see adopted by the State?—I think there should be a scientific department of the State, which should have the control of the money expended by the State upon scientific matters.

10,814. Do you think that such a department ought to be under the control of a person, himself possessing scientific knowledge?—I think it should.

10,815. Should it be a permanent Government official?—A permanent Government department, and the appointments not changed with the change of ministry.

10,816. Some arrangements of the same kind, with the same objects, have been suggested by other witnesses; but I think it has generally been held to be a matter of indifference that the head of the department should be himself a scientific man, and that the result might be obtained by appointing a Minister, with the assistance of a scientific council. Does that strike you as a good plan?—That, I think, would also be a good plan.

10,817. You think that that would answer the purpose as well as placing the department under a scientific man?—I think it would answer the purpose.

10,818. Have you considered how you would constitute such a council?—I have not. I am not prepared to give evidence upon that point.

10,819. Do you think it advisable that Government assistance should be given to any existing institutions?—Upon that point I could speak less definitely, but I think it might with advantage be given to some of the large institutions in the provinces. That a sum of money might be given to each of the leading scientific institutions for the purpose of making experimental research, and that it should be part of the duty of the Professors in those institutions to make such research. That would secure a superior class of scientific teachers throughout the country.

10,820. You are not prepared with any specific recommendations on that point?—No, I am not.

10,821. Are there any other measures which you would like to see adopted?—Those are the two chief points upon which I wish to speak.

10,822. Are you of opinion that there is much less original research in this country than on the continent?—I know there is.

10,823. To what do you attribute this?—I am not prepared to say what is the cause of it, excepting in a general way that science is much less encouraged in this country than it is on the continent. On the continent the State encourages it, whereas in this country the State does not encourage it.

10,824. What is the shape in which encouragement is afforded on the continent?—By the establishment of large laboratories and polytechnics in different parts of the continent. I have been over some of those buildings, and they are very fine institutions, very fully and completely fitted up.

10,825. They are chiefly for teaching as well as research, are they not?—They are chiefly for the purposes of teaching. I have brought with me some plans of some of those institutions if the committee would like to look at them. Here is one of the great institutions at Aix-la-Chapelle (*handing in the same*). It has been recently built, and I think that building has cost upwards of 76,000*l.*

10,826. Is it for teaching several branches of science?—Yes; a number of branches of science, and it has a large laboratory separate from the main building.

10,827. (*Professor Smith.*) Who is the Professor of Chemistry there?—I am not aware who is the Professor at Aix-la-Chapelle.

10,828. (*Chairman.*) Have the teachers in those institutions much time at their disposal for original research?—I believe they have, and they have apartments in most cases set apart for that special purpose.

10,829. Is this a newly constituted institution?—It is quite recent, 1871; it is one of the most recent. Its foundation-stone was laid by the Emperor of Germany, I believe.

10,830. Is this entirely a State institution?—I believe it is entirely so. I have also a plan of the laboratory of Berlin (*handing in the same*), that also is on the same style. I have been over that institution, and it is very complete, I believe, in all its arrangements for chemical purposes.

10,831. (*Dr. Sharpey.*) That is connected with the University of Berlin, is it not?—Yes, it is; it is some little distance from the University, but I believe it is connected with the University at Berlin. The largest laboratory, I believe, that the Saxon Government has erected is the one at Leipsig, of which I have these drawings (*handing in the same*).

10,832. (*Chairman.*) The Berlin institution is solely chemical, is it not?—Yes, solely chemical.

10,833. But the one at Aix-la-Chapelle is for a great number of sciences?—Yes, for a number of sciences; and there is a separate laboratory specially for chemistry. I do not think there are large drawings issued of the Leipsig one.

10,834. But the one at Leipsig is on a still larger scale?—It is the largest laboratory, I believe, that they have on the continent.

10,835. This laboratory is also connected with the University, is it not?—Yes, it is; but the University, as in the case of Berlin, is some little distance away from the laboratory. There is the Greifswald laboratory in Pomerania, which is another State institution (*handing in some drawings*). There is also a large Polytechnic school at Carlsruhe, and also at Stuttgart, of which I have the programmes (*handing in the same*).[*]

---

[*] List of Papers handed in:—

Die Polytechnische Schule zu Aachen entworfen, von Robert Cremer. Berlin, Verlag Ernst und Korn. 1871.

Das neue Chemische Laboratorium zu Berlin von Albert Cremer. Berlin, Verlag von Ernst und Korn. 1868.

Das neue Chemische Laboratorium der Universitat Leipsig, von Hermann Kolbe. Leipsig, F. A. Brockhaus. 1868.

Das Chemische Laboratorium der Universitat Greifswald, von G. Muller. Berlin, 1864. Verlag von Ernst und Korn.

Der hohere Polytechnische Unterricht in Deutschland, in der Schweiz, in Frankreich, Belgien, und England. Von Carl Koristka. Gotha. Verlag von Rud Besser. 1863.

Programm der Koniglichen Rheinisch Westphalischen Polytechnischen Schule zu Aachen.

Programm der Grossherzoglich Badischen Polytechnischen Schule zu Carlsruhe.

Vorschriften fur die Studirenden der Grossherzoglich Badischen Polytechnischen Schule zu Carlsruhe.

Die Polytechnische Schule zu Hannover, von Karl Karmarsch.

Programm der Polytechnischen Schule zu Munchen.

Programm der Koniglich Wurttembergischen Polytechnischen Schule zu Stuttgart.

G. Gore, Esq., F.R.S.

3 May 1872.

10,836. Most of them are comparatively of recent establishment?—Yes; I have mentioned that they are recently built, the Berlin one, the Aix-la-Chapelle one, Carlsrühe and Stuttgart and Bonn are all comparatively recent.

10,837. Do you imagine that a much larger proportion of the population of Germany is engaged in original research than in this country?—I do not know with regard to the proportion, but the actual number, I believe, is much greater.

10,838. It is your opinion, is it not, that very few persons are wholly engaged in experimental research in this country.?—Extremely few; I should say not one in a million of the inhabitants.

10,839. Are those who are engaged in research on the continent paid for it by the State?—Not that I am aware of.

10,840. Is it solely the love of science that is their inducement for making those researches?—I believe so.

10,841. (*Dr. Sharpey.*) The great laboratory at Bonn is primarily intended for instruction, is it not? —I have been over it, and I believe it is intended for that purpose entirely.

10,842. There is every accommodation for original research, but it is not the primary object of the laboratory? — No, not by any means the primary object.

10,843. And the Polytechnic school at Stuttgart is scarcely intended for original research?—No; I do not think any of the institutions to which I have referred are intended for that purpose solely.

10,844. (*Chairman.*) Not intended solely, but partially, I presume?—They are available and are used by the professors and by the students for that purpose.

10,845. This great building at Aix-la-Chapelle, which has cost 70,000*l.*, would hardly be considered to be intended simply for teaching, would it?—It is almost entirely for teaching purposes, simply with opportunities for research. There are rooms set apart for that purpose for the use of the teachers and students; but not any large portion of the building is devoted to that purpose.

10,846. Can you give us your opinion as to the reasons why science is less cared for in this country than on the continent?—I think it is because of the greater general ignorance of science in this country by the upper classes, and because the Government in this country has not, like the Prussian Government, aided it. The Government of this country, I believe, has established scarcely any scientific institutions, whereas the Prussian Government, as we know, have established a number of them in different parts of Prussia.

10,847. Have you any suggestions to make as to how a change in public opinion on those subjects could be brought about?—It could only be, I think, by very general means, by science being encouraged by the State, and by science being more encouraged at our universities. It strikes me that the root of the evil lies most at the universities where the upper classes are chiefly educated.

10,848. What change would you like to see adopted in the universities?—I should like to see scientific head-masters of all schools throughout the country, and I should like also to see a scientific department at the colleges of the universities.

10,849. Are you acquainted with the present state of teaching in the universities?—Not much so, excepting from what I have read.

10,850. But you are satisfied that science is not sufficiently regarded?—I do not think it has been sufficiently regarded, because the gentlemen who come from there, and who become the head-masters of nearly all the grammar schools throughout the country, have very little knowledge of science.

10,851. (*Professor Smith.*) Have you formed any idea of the number of scientific persons for whom you would wish to provide in the way you have described?—It would be, in my opinion, a very limited number.

10,852. You would not propose to provide those persons with a mere subsistence, but you would render them, if I understood you aright, those places objects of desire to scientific men?—They should be salaried officers.

10,853. Paid at the same rate as the upper classes of the civil servants of the country?—Something of that kind.

10,854. But you do not contemplate that the expense would be very great, on account of the numbers being very limited at present, as you imagine? — I think that the expense would not be very great, because the number of gentlemen capable of doing such work, and required to do such work, must necessarily be rather limited. I do not think that a great number of persons could be employed in that way.

10,855. Do you not think that among the chemists of the country there are very many persons who would be applicants, and really very well qualified applicants, for such places?—Not a great number, I should think.

10,856. May I ask what you mean by a great number?—Perhaps a dozen, or perhaps 20 at the utmost.

10,857. Do you not think that if those places were created the number of applicants for them, and the number of persons who would be desirous of obtaining them, would greatly increase?—Perhaps so; but I think that persons should only be appointed to such places who had obtained a considerable repute in that occupation.

10,858. And you think that it would be easy without injuring the independence of the scientific world, to distribute places of that kind amongst scientific men?—I do not apprehend that there would be a very great degree of difficulty in doing so.

10,859. You do not think that the kind of patronage which you would be placing in the hands of some official body, however well advised, would be injurious to the independence of men of science, and would be felt to be so by men of science at large?—I think not; I think that a scientific man would feel that he had earned his living in doing his work, because of the great national benefit which arises from such work, and therefore he would not feel himself in any way degraded by receiving payment for what he had not earned.

10,860. Have you considered at all the question whether the interests of scientific education would not seriously suffer by your detaching in this manner altogether from education some 12 or 20 of the best scientific men in the country?—I think that it would have a very opposite effect. I think it would induce many persons to enter into the subject of original investigation, and that we should thereby get a better class of teachers. I think that an investigator makes a more accurate teacher of science, decidedly, than a man who has made no original investigations. A man who has not made original investigations, simply follows the representations laid down in books. Now the books simply tell how you are to succeed; they say nothing about the ways in which experiments may fail, and if a person simply does as is set down in the books, and if the materials or the forces are in any way in the slightest degree different, he does not know what to do, but an investigator is much more familiar with the sources of error.

10,861. In other words, you think that every teacher of a higher kind ought to be an investigator? —I do think so, most decidedly; it is a most important point. It would make the teacher much more accurate, because thereby he gets disciplined in the detection of errors far more generally than he would as an ordinary teacher.

10,862. Do you think that the scientific instruction could be so organised as to leave your teachers time for original research?—Yes, that has already been proved by experience. Various gentlemen have been occupied in teaching a portion of their time, and occupied in investigations another portion of their time.

10,863. But you do not think that the best arrangement; you think it desirable that on the whole there should be a number of persons who should be entirely relieved from the duty of teaching?—I think that there should be a certain number entirely relieved from the duty of teaching, and employed entirely in making abstract original researches.

10,864. You do not think that any difficulty would arise in that arrangement?—I daresay difficulties would arise, but I do not think that any of them would be insuperable.

10,865. The difficulty that I wished to direct your attention to was this, that sometimes a most important course of inquiry may occupy many years (and there are instances of it in scientific history), but may lead to no results at all?—That could not be, because in any case a considerable amount of new knowledge is gained, which finds its way into the text books, and the instruction becomes available for use in all the teaching institutions of science throughout the country.

10,866. There are many series of experiments undertaken which only lead to a negative result, and which hardly add anything to the stock of scientific knowledge, and although it may be most important that they should have been undertaken, they can hardly be said to have been anything but unsuccessful courses of inquiry?—A negative result is, in my opinion, sometimes extremely valuable. I do not think that such researches properly conducted are barren of results in any case. You cannot tell beforehand what you may find, but you are sure to obtain new knowledge. If the investigation is properly selected and properly conducted, you are certain to obtain new knowledge; there is no doubt at all about that, I think, and *that* knowledge is available for teaching purposes throughout the kingdom, and is available for inventors to apply in the form of inventions to some useful purposes. I do not see how the manufactures of this country are to be improved unless original investigations are carried on, and the results of them converted into inventions by inventors and carried on in trade by manufacturers and others.

10,867. Then you have no doubt that the researches of the workers placed in those laboratories would in all cases be scientifically useful?—They would be valuable, undoubtedly, as scientific knowledge, and as knowledge to be used both for teaching purposes and also as the basis to form inventions to be afterwards applied in manufactures and trades, and in other ways. I think that would be the great use of those proposed national laboratories, to supply knowledge for inventors, to be afterwards put into the form of inventions for useful purposes, as well as for educational use.

10,868. Would you allow an investigator, paid by the State, to patent any process that he might discover in the course of his inquiries?—No, I think not.

10,869. You would exclude him from that source of emolument?—Yes, I think so. All the knowledge that he obtains I should consider as national property.

10,870. (*Sir J. P. Kay Shuttleworth.*) Have you at all thought of the soporific effects which sometimes ensue from an endowment; take, for example, what has occurred to a man getting a considerable fellowship perhaps in a special college, or in the theological function getting an exceedingly large living; do you think it not possible that some people might go to sleep upon their labours?—I do not know what to say about that. I think it is very likely that some might do so.

10,871. Supposing, having found your Faraday, and given him 1,500*l.* a year as a civil service emolument, that after 12 years he did nothing, what would you do?—I think he should be removed, most decidedly, in a case of that kind. I do not think that such a man as Faraday would be likely to fall into such a state as that; but there are some men, no doubt, who would, and I think that power should be taken to remove them.

10,872. (*Professor Huxley.*) Do you not know that there are men of very considerable power and very considerable eminence who cease to work, not on account of becoming lazy, but simply from a sort of nervous apprehension of being wrong, and a great dislike to publishing?—I am not aware of any such case.

10,873. Have you never in your experience found men who would rather go on working and getting results themselves and not publishing them?—I have not met with any instances of that kind, and I do not know that such cases have occurred. I think it would undoubtedly be incumbent upon a gentleman in such a position to publish his results. All the knowledge that he obtains I should look upon as national property, and it would be part of his duty to publish the results, and if he ceased to do so, even though he got them, I should say that he would be failing in his duty in a most important respect, and if he did so he should be removable.

10,874. (*Dr. Sharpey.*) I understood you to say that you would allow each inquirer to select his own line of research?—Within certain reasonable limits; that is to say, if he undertook to make investigations in chemistry, the investigations should be in chemistry, and he should be at liberty to take any parts of chemistry that he thought he could make discoveries in.

10,875. (*Chairman.*) I think you have told us that you are not aware that there is any such institution anywhere in the world as you would like to see established?—I do not know of one.

10,876. But still in Germany there is a large amount of original research?—There is, I know.

10,877. The establishment of such an institution is not essential, therefore, in order to the encouragement of original research?—I recommend it because I think it would be the most perfect way of aiding science.

10,878. You would prefer it to any amount of assistance given to existing institutions?—Yes, I should; and I think there should be assistance given to existing provincial institutions also. I suggested that it should be given to the chief scientific institutions throughout the country for the purposes of abstract original research, and that it should be part of the duty of the professors in those institutions to make such original research, and by that means we should get a superior class of teachers for the upper scientific institutions of the country.

10,879. Have you formed any views as to how the Government could best aid those institutions?—I have not gone into detail upon this question.

10,880. Do you think that the aid should be given in the shape of a direct money payment, or should they provide assistance in the shape of apparatus and buildings?—I think that a direct money payment is more advisable than apparatus, but that it should be a part of the duty of the Professors to make such researches, and that if they ceased such researches or to publish such researches as they have made, the payment should be withdrawn.

10,881. How far at present in existing institutions have those engaged in teaching sufficient leisure at their disposal to give a portion of it to original research?—It varies greatly in different cases. There are some gentlemen who occupy a large portion of their time in original research under existing circumstances. It occupies a large portion of my time in making original researches. I have furnished the Commission with a list of the researches which I have made, and which will show that a great deal of my time must be occupied in that kind of way, and they have occupied a very large portion of my time, perhaps more than one half of it during the last 20 years or more.

10,882. What facilities have you had for engaging in those researches?—The facilities have been by aid received from the Royal Society out of the Government Grant Fund.

G. Gore, Esq., F.R.S.

3 May 1872.

10,883. Have you had access to a good laboratory?—I have not. I am consulted by manufacturers, and those manufacturers and others pay me for my labour at a high rate, which enables me to defray a portion of the expenses of those original researches, that is the chief way by which I obtain the means for making those researches, also a small salary which I receive for teaching.

10,884. Would access to a good laboratory have been of great assistance to you?—At one time it would.

10,885. Is there no provision made in Birmingham for the encouragement of scientific research?—Not the slightest.

10,886. But might not your own case be adduced as an example that it is possible under existing circumstances to do a great deal?—It might be adduced as such an example.

10,887. What should you say in reply, if your own case were adduced as such an example?—I should say that it was certainly the duty of the State to have assisted me with funds for carrying on those researches, which are in their nature beneficial largely to the nation and not at all to myself. The whole benefit of my researches is of a national character.

10,888. You have derived very little direct advantage from your researches? — Very little direct advantage; the only advantage I get is additional repute, which induces manufacturers and others to pay me at a higher rate than they would otherwise pay me; that has been the chief advantage which I have derived from it, excepting the fame of the labour.

10,889. (*Dr. Sharpey.*) Have you formed any clear opinion as to the relative advantage of providing laboratories such as you suggest, by the State, in which original inquirers might work, or supplying men who are devoted to original inquiry with money grants from time to time to enable them to carry on their researches, and allowing them to find a locality where they could?—I think that so far as benefit is derived by the nation, the State ought to provide the whole of the means and pay for the labour also.

10,890. I am assuming that in any money payment by the State, a part of it would go to paying the expenses of the investigator, for accommodation in some existing laboratory?—That he would be as well paid, as I understand you, as if a Government laboratory were built for him; in that case I should have a difficulty to say which I should prefer.

10,891. The question is, the expediency of establishing a laboratory which, perhaps, might not always be employed; you yourself, I think, are not at all clear as to the advisable scale of such a laboratory. Might not the Government be led to lay out a large sum in establishing a laboratory, which should, perhaps, turn out not to be sufficiently occupied, whereas by simply bestowing grants of money upon men who had proved themselves capable of conducting investigations, those men might find the means in other establishments for carrying on their work?—I think that the plan of greatly extending pecuniary aid to scientific investigators of repute would be very advantageous, and would certainly be worthy of a trial if the greater plan of building laboratories were not carried out.

10,892. I am referring of course to laboratories of research, and not laboratories for instruction?—There would be, I think, greater advantages for carrying out researches if the laboratories were properly built for the purpose of investigations. Those that are at present used by private individuals are frequently made in places that are highly unfit for the purpose, and in that respect a well appointed laboratory would be a great advantage, but I think that an increase of the money grants to investigators of repute so that they should not only be paid for the materials that they use, but also be paid for their time and labour, would be a very great assistance to scientific men.

10,893. Do you think that that would be the most thrifty way of applying the public money?—I think it would be the safest method of procedure before a larger scheme was carried out, and I should be very glad indeed to see such a plan adopted of giving a greater pecuniary aid to original investigators.

10,894. Do the Commission rightly understand you to have a decided opinion of the way in which the Government should be advised as to outlay on behalf of science?—I think that the most competent body to advise the Government with regard to scientific matters would be the Council of the Royal Society.

10,895. Would you, nevertheless, contemplate the creation of a distinct body connected with the Government who should advise it?—I think so. I think that would be very desirable, as far as I have considered the matter.

10,896. A council of science, so to speak?—Yes, a council composed of really scientific men.

10,897. (*Sir J. P. Kay-Shuttleworth.*) Supposing such a council of scientific men to advise the Government to exist, and supposing the Government also to have the instrument of public laboratories in some public position, which plan should you prefer, that there should be persons appointed for the purposes of original research with permanent emoluments, or that there should be grants made, upon the advice of the scientific council, to persons who wanted to undertake in the public laboratories specific scientific investigation?—I should think that the former plan would be much the best; that there should be permanent investigators, men who had shown that they were capable of making such investigations, men of repute in their occupation, and removable in case they either failed to make investigations, or making them, failed to publish them.

10,898. (*Chairman.*) You are aware, of course, of the existence of the Government grant of 1,000*l.* a year which the Royal Society have had at their disposal for the encouragement of science?—Yes, I have received sums on various occasions which, I believe, came from that fund.

10,899. Do you approve of that principle?—So far as it goes I approve of it, but I think the sum very insufficient, simply because it not only allows nothing for the time or the labour, but it does not even cover the expenses that are incurred in purchasing materials. I received 150*l.* some two or three years ago for some investigations on fluorides, and I had to expend at least 300*l.* or 400*l.* upon those investigations, towards which I only received that 150*l.* I have had to purchase between 200 and 300 ounces of platinum vessels, to say nothing of other things, and those platinum vessels cost me nearly 30*s.* an ounce. There is a case in which the sum has been totally insufficient to pay even for the materials used.

10,900. (*Dr. Sharpey.*) Of course you have the platinum?—Yes, I have the platinum; but there is this consideration, that I have to send back this platinum continually and have it changed, and have new vessels, and I have had to pay in exchanging as much as 48*l.* or 50*l.* in a single quarter of a year, and the investigation has been going on now for seven or eight years.

10,901. (*Chairman.*) Do you think that if the system were extended to a considerable degree, a great deal of good might be done?—Yes, I think so.

10,902. Simply by an enlargement of the present system?—Yes, I should strongly advocate that the present system should be enlarged, so that the investigators should not merely be reimbursed for all that they have expended, but also paid in some measure for their time and labour, because each investigator has to give up a profitable employment in order to find the time. I refuse a great many engagements in analyses and other scientific matters for the manufacturers who come to me, and pupils and classes that I have given up on many occasions. I gave up some pupils a short time ago to enable me to have more time for original investigation.

10,903. (*Dr. Sharpey.*) Have you commonly found that you received a smaller grant than that which you applied for?—Never.

10,904. Have you always got what you asked for?

G. Gore, Esq., F.R.S.

3 May 1872.

—Except in one instance I obtained what I asked for, and I never received less than what I asked for. If I had applied for a larger grant, or asked for more frequent grants, I do not know whether I should or should not have received them.

10,905. Do you think that the sum of 1,000*l.* is really sufficient to supply the aid required by scientific men?—Not if it were applied in the way that I proposed.

10,906. I mean for the maintenance of the investigator as well as paying the expenses actually incurred for the object?—I think that it ought to be extended so far as to include payment for the time and labour of the investigator.

10,907. Do you think it would be equally easy to administer it for that purpose?—I have had no experience in the administration. The members of the Council of the Royal Society would, I think, be better able to answer that question than myself.

10,908. (*Chairman.*) Is there any disposition amongst the more wealthy manufacturers of Birmingham to do anything towards the encouragement of original research?—A short time ago I had it in contemplation to get a fund raised in Birmingham for the purposes of original research, and I made inquiries of a number of leading gentlemen there, such as Messrs. Chance, Mr. Josiah Mason, who is a very wealthy man, and others, and there appeared to be a great willingness to give money, and aid in any way that they could towards the raising of such a fund; and I have thought over the matter more fully since, and I have come to the conclusion that as the whole benefit of such labour, though it might be paid for by money raised locally, would be for the benefit of the country, therefore there was no duty on the locality to raise money for labour of which the benefit would entirely go to the nation. I should have succeeded, I have very little doubt, in raising a fund of a moderate amount in Birmingham and the locality for such a purpose had I continued the movement.

10,909. (*Professor Huxley.*) Would the benefit of the fund entirely go to the nation; do you mean to say that Birmingham would be excluded from this benefit?—Birmingham is a part of the nation, and only as such could Birmingham derive benefit from the results of original research.

10,910. But might not Birmingham contribute its quota as a part of the nation?—Birmingham already contributes to the national exchequer, and any fund coming out of the national exchequer for original investigation ought partly to go to Birmingham as well as the other parts of the country.

10,911. That I quite understand, but I do not see exactly why it is an argument for the Birmingham people not doing anything whatever in the direction of promoting science?—The argument would simply be that though the locality had raised the sum of money the benefits derived from the use of that money would not be limited to that locality, but would go to the whole nation.

10,912. Are you of opinion that as a general principle the locality should do nothing except towards benefits which are confined to itself?—It strikes me that that is a principle of justice, and that if they raise the fund they are entitled to the benefit of it.

10,913. But the locality makes its own roads, does it not?—I believe it does.

10,914. But the benefit of those roads is not confined to the locality; if I travel in the neighbourhood of Birmingham I have the benefit of the roads?—It is very true, but the great benefit of the roads is to the locality, I apprehend.

10,915. Would it be a reason for the locality making no roads because they might be beneficial to somebody else?—Perhaps not.

10,916. Do not you think that the same thing applies to the case in point?—I think not, because the benefit goes to the whole nation, whereas in the case of the roads the benefit is mainly restricted to the locality.

10,917. But in the case of scientific investigation being pursued in Birmingham, which is a large manufacturing centre, the benefit of the application of science to manufactures is so great, and so obvious, that Birmingham would surely be vastly more benefited by scientific investigation carried out, and teaching given there, than Buckinghamshire would, so that the benefit would not be to the whole nation?—That would depend entirely upon the inventions which would ultimately be developed from the discoveries made by means of that local fund; they might be of a character from which Birmingham would not derive any special benefit, and very likely would not.

10,918. Would you really limit the help given by the locality to scientific pursuits to those which you think can be shown to be directly beneficial to the particular localities?—I think that that ought to be a prime idea in the case. If the investigations made with the money contributed by a locality were directed specially to the metals or substances used in the works in that locality, the case would be very different.

10,919. (*Chairman.*) It might naturally be expected that any researches the Birmingham manufacturers themselves directly engaged in would be primarily with a view to their own branches of manufacture?—That, I think, must partake more of the nature of an invention which is quite foreign to the subject, and which ought to be kept quite distinct from the subject of abstract investigation. [*See* APPENDIX X.]

The witness withdrew.

WILLIAM B. CARPENTER, Esq., M.D., F.R.S., further examined.

W. B. Carpenter, Esq., M.D., F.R.S.

10,920. (*Chairman.*) Are you of opinion that it is important to provide greater encouragements for the study of biological science than there are at present?—I cannot see that there is any encouragement at present for the prosecution of biological science. I can only speak from my own experience, that when I desired as a young man to devote myself to that study, and had given (I think I may say) some evidence of capacity to promote it, I had to consider how it was possible for me to gain a livelihood; and I found that the only mode in which I could obtain the means of devoting myself to that science, was by popularizing, as far as I could, certain portions of it in writing and lecturing, that I might obtain a small fraction of time to give to original inquiry; and I do not think that as regards biological science there is much greater opening now. There are prospects, I think, in the Universities of greater openings; but at present these openings are limited to a very small number.

10,921. Do you think that biological science is in a worse position as far as encouragement is concerned than any other department of science?—It is much worse than Chemistry, for example; because in chemistry there is encouragement by the very extensive demand for teaching in the first place, and in the next place by the demand for the practical application of chemistry, which pays extremely well to those who choose to undertake it; but there is no corresponding application of biological science.

10,922. Can you suggest any measures by which such encouragement as you think desirable could be afforded?—I think that in the first place the provision either by the State or by the funds of the Universities of means for carrying on original research in physiological laboratories is a primary desideratum; but a provision for the maintenance of those who would carry on such researches is of course essential. In Germany, where the number of Universities is very large, and the number of Professorships of various departments of biological science is very considerable, I do not think that a young man who has shown a capacity for cultivating any department of biological science, and who has successfully prosecuted researches in it, need wait long for the means of obtaining a livelihood. I have seen within my own observation a number of cases in which men who had begun as *Privat-docents*, have, in the course of a few years, been advanced to valuable professorships. The large number of such professorships that there is in Germany, of course, affords a greater opportunity for the promotion of men who have really shown adequate ability.

10,923. Are there any other openings on the continent besides professorships for persons of eminence for their biological knowledge?—I am not aware of any. In Geneva it is rather the habit, as it is to a considerable extent amongst us in England, for men of independent fortune, having a scientific taste, to devote themselves to the prosecution of scientific inquiry. But as far as my knowledge extends, there are comparatively few cases of that kind in Germany or France. It is more in both these countries a profession.

10,924. Are all the professors in the Universities expected to teach as well as to engage in original research?—As far as I am aware they are.

10,925. In what way would you consider that the State might provide assistance or encouragement?—I think it very important that the State should provide the means of carrying on those higher researches, and that higher teaching, which are not provided for in any shape at present. In our medical schools, for example, in London, there is a certain order of teaching which is based upon the requirements of the candidates for medical degrees; but there is no provision whatever for teaching of any higher or more special kind. Such teaching will never pay; there would never be a class of persons, at least as far as we can see at present, who would make it worth while for any Professor to devote himself to the exposition of the higher departments of biological inquiry. The whole oral teaching of Chemistry, for example, is at present based on the requirements of medical students; and any man who wishes to obtain higher teaching is obliged to go abroad for the purpose of obtaining it. The only institution at which any higher teaching is given is the School of Mines; and even there the course of lectures, as far as I am aware, must be considered an almost elementary one. I think, therefore, that the State should, either through the existing machinery, or by the institution of some new machinery, concern itself with the teaching of that higher and more special kind which no existing institution gives, and which no existing institution can be expected to give, because there is no pecuniary inducement to any one to devote himself to it.

10,926. Do you think that the existing machinery, with Government assistance, might be made to answer the purpose which you have in view?—I think, for instance, that a body like the University of London might very advantageously be empowered to take up such higher and more special teaching. At present the University of London has nothing to do with teaching. The principle of the University is to recognize existing institutions; and although as regards arts and science we do not now require attendance on any institution, we do still require attendance on lectures for medical degrees. And I do not think that it would be at all the function of the University to interfere or compete in any way with the institutions which it recognizes. But I should myself be very glad to see the University empowered to carry out courses of instruction of a higher and more special kind than are given in any of the institutions affiliated to it.

10,927. And not solely in biology, but in other departments of knowledge?—Yes; in other departments also. I confine myself to biology because that is my own special subject.

10,928. That would be a great departure, would it not, from the present constitution of the University and from its original intention?—Yes. I merely speak of that as presenting an existing machinery. There is a body of men of very high culture meeting frequently for the purposes of promoting academical education, the Senate of the University; and it seems to me that it would be a pity not to utilize such a power as that, in a body already having a high consideration in the country, for the sake of promoting this higher object.

10,929. Would you contemplate the establishment of departments for the higher teaching in existing institutions, or the establishment of new institutions altogether?—I should myself look to the development of the School of Mines for example, in the direction I have spoken of, as one most important means, perhaps the most important in London, of promoting such an object. But I think that the Universities of Oxford and Cambridge, with their large funds, might also do a great deal more; the principal point there being the encouragement given to men who might show a high proficiency in their academical course, and subsequent encouragement given to them to continue to prosecute research, by the appropriation of fellowships, or something equivalent, to those who had obtained such distinction. That is, as the Commission no doubt are aware, already done to a certain extent; but to an extremely limited extent, and I may give an instance of the way in which that limitation works, which came to my knowledge only a few days ago. A Science scholarship was open at Christ's College, Cambridge; and one of the fellows of Christ's College expressed great regret to me that they had only one candidate for it, although the scholarship was a good one. It happened that the candidate was a very competent one, and obtained the scholarship; but it was to be regretted that there was no competition. I asked him what prospective advantage would be given; whether they were prepared to offer a fellowship to a science candidate who distinguished himself in his academical course; and he said that they had not resolved upon that yet. Then I said, "I do not think you can "expect to attract good science candidates, unless you "have a prospective advantage, in the form of a "fellowship, to offer, as is offered at Trinity "College for example, and I believe at St. John's." He quite assented to that view, and hoped that Christ's College would appropriate a fellowship for the encouragement of science. That is one of the modes in which, as it seems to me, the Colleges, without any departure from their existing constitution, or rather the Universities as consisting of colleges, may very greatly encourage science by giving those fellowships, not as rewards for the mere acquirement of knowledge, but as means of maintenance to those who are able, competent, and willing to advance science by original research.

10,930. Are you of opinion that Government assistance might be given extensively in any direct form to individuals for the prosecution of scientific inquiries?—That is a point upon which I feel very strongly, from the experience which I have had in the last four years of carrying out inquiries by the assistance of Government. There are certain large inquiries for which no limited grants can possibly avail, which require very large machinery to carry them out effectually, and a large staff of competent scientific men. The inquiries in which I have myself had an opportunity of taking a share, have been prosecuted by the liberal assistance of the Government, as regards the *materiel*. A ship has been supplied, and opportunity has been given to scientific men, to carry on these inquiries into the condition of the deep sea for a limited period; no remuneration has been given to the scientific men concerned, who have acted merely as volunteers; and if it had not been that I held an appointment which gave me a certain vacation which I could employ in those inquiries, I could not myself have taken part in them; I could not have given up any avocation to obtain time for the prosecution of them; all that I have done has been done strictly in a slightly prolonged vacation. But the Government has acceded to an application made by the Royal Society for the more

W. B. Carpenter, Esq., M.D., F.R.S.

3 May 1872.

extended prosecution of the same inquiries with a competent staff of scientific men paid out of the public purse; and I think that that is an example which is deserving of consideration, and is one that might be brought forward as a type of what the Government may be expected to do. I know that it is the view of the Chancellor of the Exchequer, that what can be left to private enterprise in the prosecution of scientific inquiries, private enterprise ought to do; but that what is beyond the means of private enterprise, and only a Government can do, a Government ought to undertake.

10,931. Do you think it is desirable that a department of the Government should be constituted whose business it should be to consider applications on such subjects?—I think that there should be a body in direct connexion with the Government, to which such applications should be referred, and which should be considered as a consultative body. But I do not see that any other body of that kind is needed than the Council of the Royal Society. I think that constituted as that Council is, it contains representative men of all departments of science who are perfectly qualified to be the advisers; and I think that there is a great advantage in having any question of that kind discussed, not merely by the representatives of one department of science, but by the representatives of the scientific body generally,—the *corps scientifique* of the nation. Under the present constitution of the Royal Society, the Council of the Royal Society may be regarded as a very true representative of the scientific life, so to speak, of the nation. It would doubtless, if it saw occasion, seek the advice (as it does at present in the administration of the Government grant) of competent men outside its own body.

10,932. In the instance to which you referred just now, did the Government undertake to make those inquiries on the recommendation of the Council of the Royal Society?—Yes.

10,933. In that instance did the application proceed originally from the Royal Society, or did the Government ask their opinion?—The original proposal was made by myself to the President of the Royal Society, the origin of my proposal being a suggestion made to me by Dr. Wyville Thomson that we might apply to the Government for the means of carrying on researches of this kind. I said, "I think that "the application will be best made through the "Council of the Royal Society; if I can induce the "Council to take up the subject, I think it is much "more likely that the Government will attend to "a recommendation from it, than it would to a request from you and myself personally." I brought the matter before the President of the Royal Society, and he placed it before the Council. The Council agreed to the application; the application was made to Government, and was at once assented to. That application was renewed in two successive years, and on each occasion was assented to without hesitation. A larger application for a three years' Circumnavigation voyage originated with myself personally, but on my assurance to the First Lord of the Admiralty that I felt no doubt whatever that all the great scientific bodies interested in it would unite in a formal application, if he thought such an application desirable. He informed me that after considering the question, the Government would be ready to take an application from the Council of the Royal Society alone into favourable consideration; which was tantamount to saying that nothing more was needed than a formal application to that effect; because I was able to assure him that the results of our previous work had been such as to satisfy the general body of scientific men in this country, as well as scientific men abroad, that the further prosecution of those researches would be likely to be attended with results very important to science; and I feel therefore a very strong conviction that whenever the Government can be assured upon evidence which they feel they can rely upon, that their assistance can be advantageously given for the promotion of science, that assistance will be forthcoming.

10,934. To a certain extent, at least, you think that the present state of things is not unsatisfactory?—It is not unsatisfactory except in this, that there is no systematic arrangement for the promotion of science.

10,935. But it is rather an accident what they take up and what they decline to take up?—Yes; nothing could be more liberal than the manner in which this Circumnavigation Expedition is being provided for. If it is contrasted with what the American Government, for instance, have done, I am quite certain that our own will be found to have very great superiority. The American Government have assigned a small vessel, of which I hear from good authority that one week's work has had to be followed by three weeks of refitting. Our own experience, with the vessels hitherto assigned to us, has been entirely satisfactory; and I know that in the preparation of this Expedition nothing will be spared either in the size and equipment of the vessel, in the selection of the officers and men, or in the general fitting out, to make it thoroughly worthy of the country.

10,936. Do you think that cases would be of frequent occurrence in which it would be important that Government aid should be afforded for carrying on scientific inquiries connected with biological science?—I believe that by the utilization of the existing machinery, a very great deal of valuable material may be collected. If it is really understood in the Navy, that encouragement will be given to the collection of objects of scientific interest, and (so far as may be) to the study of them, I feel assured that very great advantage would result. In Bristol, where the earlier part of my life was passed, the Curator of the Museum was accustomed to interest the merchant-captains in the collection of natural history objects; and the Bristol Museum contains a large amount of extremely valuable specimens, obtained simply by merchant-captains going to the coast of Africa especially, but to other points as well. I mention the coast of Africa, because it was from that coast that some of the most interesting specimens were obtained; for instance, the first specimens of the Gorilla that were brought to this country were obtained through a merchant-captain trading from Bristol to the Gaboon river; and several very valuable specimens from other points on the coast of Africa were obtained through that machinery. I learned a year or two ago in Liverpool, that the Museum in Liverpool, which is growing up extremely fast and coming to be a most important and interesting institution, is very largely increased by the same means; its Curator endeavouring to interest the captains of the various ships going out from Liverpool in the collection of natural history objects. I may mention a trifling instance, but one of great interest, which shows how the mere keeping of what is considered refuse may sometimes be of great value. During the Chinese war, our expeditionary force was lying in the Peiho, and one of the vessels lying there had a very foul bottom, which was scraped, and one of the scrapings was brought to me. It was a mass of Polyzoa, which is commonly called coral; a mass which I was assured had grown to the size of my two fists in the course of six months. Now that alone was interesting as an instance of very rapid growth. But when I showed it to Mr. Busk, our highest authority on Polyzoa, he at once said, "This is a most remarkable specimen; for it is a "genus which was believed to be extinct, belonging to "the Suffolk Crag. To find this now living on the "other side of the world is an extremely interesting "phenomenon." I believe that the mere keeping of the scrapings of ships that have been on foreign service, taken off from the bottoms in our own dockyards or foreign dockyards, or our colonial dockyards, would be of very important service to zoological research, if only those collections were properly attended to when brought home; but at present there is no adequate machinery for utilizing such collections.

W. B. Carpenter, Esq., M.D., F.R.S.

3 May 1872.

10,937. Would they naturally go to the British Museum at present?—Some of them go to the British Museum, and some are kept by the persons who bring them home. For example, in the Antarctic Voyage of Sir James Ross, the description of the animals that were obtained by what was then the deepest dredging ever made, was never published. Dr. Hooker made drawings, and the animals were preserved. Sir James Ross always expressed his intention of publishing them himself, and he took them into his own keeping, but no one has ever heard anything of them since.

10,938. Do you think that a good deal might be done by the officers of the Royal Navy generally, without interfering with their more immediate professional duties?—I have no doubt of it, because when ships are abroad on foreign stations there is a very large amount of time during which they are literally doing nothing. I have seen that myself at Gibraltar and at Malta; and I know it is the case on the China station and on the North American station, that officers would be really glad if they had some occupation given to them. But if they had not been led to feel an interest in Natural History, of course such occupation would not be congenial to them. What I am extremely desirous of seeing is, that in the improved education of our naval officers, which I understand to be contemplated by the Government by the institution of a Naval College, there should be opportunities given for the acquirement of Natural History knowledge, at any rate for those who might choose to avail themselves of it. I do not know that it would be advantageous to make it compulsory; but there should be opportunity given to naval officers to obtain the kind of practical knowledge which would enable them to employ themselves advantageously in natural history inquiry on foreign stations, when they can do so without interfering with their ordinary duties.

10,939. Do you think it desirable that any systematic measures should be taken for publishing the results of such inquiries in cases where they were valuable?—Yes; I think that that is a very important part of the plan which I would suggest, that any collections thus made should be turned to account for the public service by the systematic study of them by competent persons at home. I think, for example, that the Professor (supposing a professor of marine natural history to be appointed to this naval college) would make himself acquainted with the capacities of the various students who passed under his observation; he would know what their ability and what their special tastes might be; he would know on what service they were likely to go, and he would have the means, therefore, of especially interesting every one in the subjects that he was best fitted to study. One, for example, would take very small microscopic animals on the surface, another might care more for collecting shells or corals, or plants; in that way he would be able to put in train a large amount of scientific inquiry; and the results being brought to him in the regular course of professional service, he would be able to turn those results to good account. The publication of them by his aid to them, or by his taking them into his own hands, as might be found most advantageous,—as the collections made by such and such an Officer,—would make it felt that such research, being prosecuted under Government sanction, was an object to which an officer might rightly and properly devote himself, of course always consistently with his professional duty. And such encouragement would give him an interest in the work, instead, as at the present time, of its being considered rather an interference with his ordinary duty. I do not think that a good Captain, a captain who had himself an interest in those studies, would so consider it; but unless a captain has a personal interest and desire to promote it amongst his subordinates, of course no encouragement would be given, and obstacles would be thrown in the way. But when we have men in the position of commanders, who have themselves a strong interest in the prosecution of scientific inquiry as one of the duties of the Navy, I cannot but believe that a very large amount of valuable material would thus be brought together. I may mention that the officer whom I understand to be already selected for the superintendence of the proposed naval college, Admiral Cooper Key, is one who has a very strong desire to turn the Navy to account in the manner which I have indicated.

10,940. With regard to Government assistance for the prosecution of scientific inquiries, I understood you to say that you were of opinion that the Government could not take advice from any better quarter than the Royal Society, but that you thought it should be done systematically; would you wish to have some systematic and permanent connexion established between the Royal Society and the Government, and that it should be the duty of the society to call the attention of the Government to any subjects upon which they thought that assistance was of great importance?—I think it should be so considered. At present I believe there is quite a disposition on the part of the Government to give a favourable consideration to the recommendations of the Royal Society; but I apprehend that the Council of the Royal Society would not feel themselves justified in moving the Government excepting for some very special object.

10,941. Would you like, for instance, that the Royal Society should be invited to make an annual report to the Government as to matters which they thought especially deserving of Government help?—I think that it would be an useful thing to have a periodical report, because it would maintain the connexion. At present it is, so to speak, simply an occasional representation; but if there were scientific laboratories, for example, placed under the direction of the Council of the Royal Society, it would be quite right that there should be periodical reports of the work done in those laboratories.

10,942. One of the witnesses who has been before us strongly urged the importance of establishing a physiological laboratory by the Government. Do you agree in this recommendation?—Yes, very strongly; because that is an object which no existing body in this country can take up, excepting the Universities, or it might be possibly the College of Surgeons. There is no body that has funds at its disposal for maintaining such a laboratory. We have in a small way, under the University of London, a pathological laboratory, for which means have been found under the will of the late Mr. Brown; but that is the only physiological laboratory in London that I am acquainted with, that can be considered a laboratory for research.

10,943. Would the establishment of such a physiological laboratory be a costly undertaking?—I think not, as regards the establishment of the laboratory itself. Some particular investigations might be attended with cost, but I have not given any attention to the details, because those will be better dealt with by others who are more competent to speak on that subject.

10,944. (*Sir J. P. Kay-Shuttleworth.*) You would probably connect it with some considerable museum already existing?—The only institutions that I can think of with which it could be advantageously connected, would be such an institution as the College of Surgeons or the Zoological Society; whether there are at present adequate facilities for carrying on research in those institutions, I do not know.

10,945. If the Natural History Collection of the British Museum were removed from its present position, might not a biological laboratory be connected with it?—Yes, if its staff were expanded to take in research of that kind. But at present, I believe, there is no idea of making it either an institution for teaching or an institution for research, but simply a collection.

10,946. (*Dr. Sharpey.*) What do you consider to be the work of a biological laboratory such as you contemplate; would it be chiefly comparative anatomy and zoology, or would it be the physics and chemistry of physiology; because the College of Surgeons is in no way particularly connected with the modern pursuit of physiology as distinguished from com-

W. B. Carpenter, Esq., M.D., F.R.S.

3 May 1872.

parative anatomy, nor is the British Museum ?—The whole science of biology divides itself into so many different departments, that one might be prosecuted in one institution and another in another. For instance, that department in which I have myself a special interest, Marine Natural History, would have to be prosecuted in a laboratory upon the coast, to be effectually studied. An observing station on some advantageous point of coast would be necessary, where the material would constantly be at hand, and where observations on development might be carried on. But on the other hand, a physiological laboratory furnished with the means of carrying on observations in physics and chemistry connected with physiology might be attached, for example, to the School of Science, supposing it to be placed on an enlarged basis.

10,947. (*Chairman.*) More than one laboratory would be required, would there not ?—Yes ; there should be laboratories for different divisions of the subject. Comparative anatomy, for instance, might be prosecuted very advantageously in connexion with the British Museum, or the College of Surgeons.

10,948. Would you propose to place Government officials in those laboratories to work in them, or would you throw them open to other persons engaged in original research ?—I think that there should be a permanent Head of each such laboratory ; but if the laboratory were established and placed under the general direction of a competent superintendent, there ought, I think, if the laboratory is supported by public money, to be opportunities of research given to any one who has given evidence of his power to carry on such research. That is what we do in the Brown Pathological Laboratory. There are at the present time pupils working there, who are admitted as having given evidence of their capacity to carry on work efficiently.

10,949. (*Dr. Sharpey.*) That is to say, in actual research ?—Yes, in actual research.

10,950. (*Chairman.*) How long has the Brown Institution been at work ?—Since the beginning of the year only. It was specially provided by the testator's will that the institution should be for the study, and as far as may be, for the cure of the diseases of animals. Therefore the Senate of the University of London has considered that the scientific study of the diseases of animals should really be a prominent object of the institution.

10,951. (*Professor Smith.*) It is an institution, is it not, which is at present distinctly made use of for the purposes of research ?—Yes.

10,952. Referring to a former part of your evidence, has the proposal which you mentioned, that the University of London should undertake the duties of higher teaching in certain directions, been entertained at all, or has it only been suggested ?—It has never been formally entertained by the Senate. I have heard the idea suggested from time to time; and a few years ago a sum of money was offered to the Senate to endow a chair for special teaching ; and that gave rise to a conversation, the result of which was that under our present charter the Senate has no power to undertake teaching of any kind. I think I may say that it would be considered quite inconsistent with the constitution of the University, that it should undertake teaching which would in any way bring it into competition as a teaching body, with existing institutions. But I heard many members of the Senate at that time express a hope that the time might come when the University might be empowered to undertake teaching of a higher and more special kind.

10,953. The Senate might at some future time endeavour, might they not, to have such lectures given in connexion with the University of London, as are now given in the College de France ?—Yes, more of that character.

10,954. You spoke also, I think, of the desirability of Fellowships in the older universities being awarded on the ground of capacity for scientific research ; there would be a difficulty, would there not, in the bodies as they exist, in the colleges themselves giving away fellowships on that ground ; I do not mean that they would have any unwillingness to do it, but that the colleges in our existing universities would feel not very competent for the purpose ?—They would become more and more so of course, in proportion to the larger infusion of the scientific element, if they were disposed to take advice at the present time,—as one college that we know at Cambridge has shown itself disposed to do. There would then be in time a considerable leaven of scientific men in the collegiate bodies.

10,955. Then you think that the proper mode of filling up fellowships in that manner would be for the colleges to obtain proper advice from the scientific world outside ? — Yes ; it may be questioned whether any external power, beyond that of public opinion, needs to be brought to bear upon them. My own impression is that it would be considered an interference which would be rather prejudicial to harmonious working ; but I know so little of the internal constitution of the colleges, that I would rather not express an opinion.

10,956. You think that the elections might be satisfactorily conducted by the existing electing bodies, they being, by the hypothesis, supposed to be anxious to do what is right, by their taking simply the advice of external bodies ?—Supposing a college desirous of conferring a fellowship upon a scientific man, and not feeling perhaps that in their own body they had the means of making the best choice, I should expect that they would take the advice of men in their own University, or outside the University, if they were really and honestly desirous of securing a valuable man. But upon that point I can really only speak from a very limited experience.

10,957. (*Professor Huxley.*) There is a practical difficulty which occurs with respect to attaching to the Scientific Department of the Admiralty an officer whose duty should be so comprehensive as that included in the fifth paragraph of your précis ; do you contemplate that the person who has to perform that duty should also be a professor at the Naval College ?—I do not wish to propose anything too extensive at first ; I should think that that department should grow, and that it might come in time to be much more than one man could undertake, if it were really developed in the mode in which I should hope. I merely mean that there should be some one whose business it should be to utilize the material thus obtained.

10,958. The fear which arose in my mind was, that if the person to whom that duty was confided were a professor in the Naval College, he would be really unable to do the amount and variety of work indicated in your scheme ; is that your impression ?—I do not think that the course of instruction ought to be a very elaborate one. I think it should be such an one as to try to give an interest in the general study, and not to go into minute detail ; because young men who are engaged in their professional education as naval officers have very little time to spare. And supposing them to be in such a position, I should endeavour rather to find out what each man's taste was, and to encourage him to cultivate it with sufficient general knowledge, than endeavour to force upon every one a wide range of study.

10,959. But the mere business of receiving and distributing specimens, and of disposing of observations, would be a very large thing in itself, would it not ?—It would come to be so ; and as it came to be, there would be a requirement for a larger provision. But my anticipation would be, that if once the advantage of such a system came to be perceived by the publication of the results obtained, and the general approval of scientific men of the working of such a scheme, there would be no difficulty in extending it. Payment by results, I believe, would be a considerable encouragement.

10,960. (*Sir J. P. Kay-Shuttleworth.*) Are you of opinion that it would be wise to depend upon the ordinary resources of the trade collectors now exist-

W. B. Carpenter, Esq., M.D., F.R.S.

3 May 1872.

ing in natural history objects for the supply of the Museums of the country?—Certainly not, because the trade collectors collect simply those things for which there is a market.

10,961. You would rely very much upon the better instruction in natural history of the officers of the Navy as being a means of collection?—Yes, and I may give the following as an illustration. Every Naturalist knows that specimens of recent *Crinoidea* are very rare and valuable. We found in one of our own expeditions a considerable number of such specimens on the coast of Portugal, which were of extremely great interest in many points of view: previously to that they had been obtained by ones and twos at a time from the West Indian islands. A naval officer assured me that at a point off (I think) the north-eastern coast of Australia, not far from New Guinea, he saw in going in a boat a whole forest of those *Crinoids* sufficiently near the surface to have easily reached them. This gentleman was struck by a specimen which I was exhibiting at a *soirée* of the Linnæan Society; and he said that he was perfectly certain that those were the things which he saw. Of course, that is the statement of an uninstructed man, and I speak of it *quantum valeat,* but I do not think it is at all unlikely. He said they were starfish waving on stems, and he could distinctly see them waving at three or four fathoms' depth under water. A collection of them would have been of enormous value to the naturalist.—I may mention another case which shows how a very little knowledge would have been of extreme value. I have sure information that some years ago, after a hurricane on the coast of Barbadoes, the whole coast of a certain part of the island was strewed with *Crinoids*, broken off and washed up on the coast. A schoolmaster in the neighbourhood observed them, and described them accurately afterwards, but was not sufficiently alive to the interest of preserving them to keep any, though the account which he gave of them was such as left no doubt (since we know that they do inhabit those seas) that those were the *Crinoids* which are the objects of such interest to the naturalist.—I may mention as an instance of what has been done by an Army Surgeon, the very valuable researches made at Malta by Mr. Adams. Being stationed in that garrison, he prosecuted a series of inquiries into the geology and palæontology of the island, which proved of the greatest interest. He prosecuted them in his leisure time; and I am quite sure that a Naval Officer stationed at Malta might find a great deal to occupy him in the immediate neighbourhood, in marine research. It would be a peculiarly good centre for the study of the Fishes of the Mediterranean, as to which there is much yet to be learned.

10,962. (*Chairman.*) Are there any further points upon which you would like to make an addition to your evidence?—I am not aware of any at present.

The witness withdrew.

Adjourned to Wednesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 8th May 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

Lieutenant-Colonel ALEXANDER STRANGE, F.R.S., further examined.

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

10,963. (*Chairman.*) Are there any points upon which you would wish to make additions to the evidence which you have already given us?—I would wish to make an addition with reference to the subject of metallurgy. The Commission may remember that I recommended that there should be a laboratory for metallurgical investigations. I think that recent examples of wants such as these may, perhaps, be of more weight than mere general opinions, and a very recent example has come to my notice. Since my first examination before this Commission there has been a paper read before the Civil Engineers' Institute by Mr. Bashley Britten, the title of which is, "On the construction of heavy artillery with reference to the economy of the mechanical forces engaged." That paper has occupied three evenings, the first evening on which it was read, and during two evenings it has undergone discussion. I was present on both of those latter occasions and heard the discussion. There was a paper read before the same institution by Mr. James Atkinson Longridge, "On the construction of artillery, &c." That paper was read in February 1860, and it was very fully discussed; the discussion lasted, I think, six or seven days. I have read that discussion, and I have heard the recent one, and I wish now to state it as my deliberate opinion that we seem hardly to have made any progress in the subject during that long interval of time. The main questions discussed 12 years ago were the materials of which large guns should be made, the forms and disposition of those materials, the character of the rifling, the relative size of the bore, and the form of the projectile, and those are the very points that were discussed last night, and no conclusion was arrived at on any one of them; and it appeared to me that the whole question was discussed in a spirit which almost excluded scientific considerations altogether. The whole tenor of the discussion was to exemplify by means of existing guns constructed according to the fancy of certain inventors, to discuss those guns, and to give the results that had been obtained with them. But there seemed to be a total incapacity, for want of proper information and for want of the experience of scientific men, to throw light upon the principles which should regulate the construction of heavy ordnance. Such a simple question as this, whether cast iron was a material that could bear the strains of great explosions or not, was one question on which there were wide differences of opinion. That question is absolutely not settled to this day, and it seems to me that this bears very strongly upon the question of a metallurgical laboratory in which experiments can be tried in a thoroughly scientific manner, which has hitherto not been the case; and it also bears upon the letter by Mr. Anderson, which I quoted in my former evidence, in which he speaks of the necessity of investigating the properties of the different kinds of iron. I would illustrate this further. Some time ago, in conversing with Sir Joseph Whitworth on the subject of his various very clever experiments on metals, I said to him, "Well, "but, Sir Joseph, why do not you experiment upon "iron?" He said, "I have been doing nothing else all my life." I said, "Excuse me, you have not performed a single experiment upon iron." I believe he thought me mad, but I explained to him that I meant pure iron, and he then admitted that he had never had a piece of pure iron in his hand. All the experiments that have been carried on in ordnance have been carried on by means of an adulterated article; an article, the adulterations of which have not been

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

measured, and as yet we do not know to what extent minute adulterations will affect the entire mass. We know that very small additions of foreign bodies to certain alloys entirely alter their character. And that branch of investigation, which is an excessively wide one, and I admit an excessively difficult one, has, I submit, not been entered upon yet by the nation, and it can only be done by national means. No private individual, no engineer, will set himself to perform those extremely costly experiments for the good of the world or of his country.

10,964. (*Professor Smith.*) Do you mean to say that the iron of which pieces of ordnance are made is not as a general rule chemically analyzed?—I believe not; and if it were, that would not throw light upon the subject, because the iron is produced by a manufacturer, and is not controlled by those who make the guns; and you can only find that there are certain things there, but you cannot ensure their being excluded or their being put there. I think that the subject is so enormously important in a national point of view, and I was so very strongly impressed with the total ignorance which seemed to prevail regarding it in this recent discussion, that I felt it my duty to mention it to the Commission.

10,965. (*Chairman.*) Have no experiments of this nature been conducted at Woolwich under the Government?—They have not been conducted, I believe, in a scientific manner; at the same time enormous sums of money have been spent upon this subject. The estimates vary, but they lie between 4,000,000*l.* and 9,000,000*l.* which has been spent upon the subject of heavy ordnance, and we are now to-day discussing whether, for instance, cast iron ought to be used or ought not to be used.

10,966. (*Dr. Sharpey.*) Could the chemical part of those experiments not be conducted in Jermyn Street?—I doubt whether the establishment is large enough; that is to say, whether there is room enough.

10,967. (*Sir J. P. Kay-Shuttleworth.*) The investigations of Sir Joseph Whitworth and of Mr. Bessemer into the qualities of iron necessary for the various forms of construction have not extended, have they, beyond the quantities of carbon or of nickel contained in the metal?—I believe not much further than that.

10,968. Can you state to what extent the existence of phosphorus in iron has been inquired into?—I have no doubt that analyses have been made of iron, and very exhaustive analyses, but that is an analysis of a particular specimen of iron, and the object above all should be to ascertain what additions to pure iron are necessary to give it certain desired qualities; and I do not think that experiments with that view have been carried on to any great extent. Then the disposition of the material is of enormous importance. Instruments have been contrived lately for measuring the force of the gases, in their first explosion, pressure gauges they are called, and instruments have also been contrived for measuring the velocity of the ball in its passage through the bore of the gun. There is a beautiful apparatus by Captain Noble, the chronoscope, which has been contrived for that purpose. But I do not know that any equally scientific means have been applied to ascertain where the strain falls upon different parts of a gun, and I believe that that might be done. I believe that means might be contrived for measuring the vibration set up by the explosion in different parts of a mass of metal.

10,969. (*Chairman.*) Would experiments on a small scale be sufficiently satisfactory? Would not it be necessary to try them on actual pieces of ordnance?—I think so, and that is one of the reasons why I have recommended the separation of the metallurgical laboratory from the chemical or the physical laboratory, because it would deal with such very violent agents that it would hardly be convenient to have it near those other laboratories. Otherwise it is part of the same subject—it is a chemical and a physical subject no doubt—but I think as a matter of convenience, and for the very reason alluded to by your Grace, it would be better to have the metallurgical laboratory apart from the others.

10,970. The result of your inquiries is that no satisfactory experiments of this nature could be conducted except by a Government establishment?—By a Government establishment, and of course highly accomplished men of science. Such experiments have been too much in the hands of what are called practical men, and the signification that I attach to the word "practical," as I hear it constantly used around me, is "ignorant."

10,971. Have you any reason to believe that more complete experiments have been made in any continental state?—I believe so, and certainly in America. The best speech made last night, the one that contained the most science, was by Captain Simpson of the United States Service. Whether he is a military or a naval officer I do not know, but he is now being employed by his government in investigating the state of artillery in Europe. He has travelled all over Europe for that purpose, and he spoke last night at great length, and his speech contained more science than all the rest put together. In America I may mention they use cast iron very largely, and it is obvious that if it can be used with efficiency, it is very desirable to use it on account of its economy. It is far more economical than the wrought iron which is used in our guns. I am afraid of occupying the time of the Commission, but another recent instance has come to my knowledge which I would mention as an example of the unsound state of public opinion regarding science now prevailing. The instance is connected with the annual dinner of the Civil Engineers' Institute, at which certain speeches were made, which led to articles in the newspapers. It is more the articles in the newspapers that I should refer to than the after-dinner speeches. On that occasion, the president, on proposing the health of Her Majesty's Ministers, complimented them for having left his profession alone. Mr. Gladstone, as Prime Minister, replied, and in the course of his speech he used these expressions: "But the doctrine "of non-intervention on the part of the Government, "which was then" (in former times) "an article of "faith held without distinction of political party, was "now, in his mature, perhaps his declining, years, no "longer unquestioned. A change was creeping over "men's habits and opinions in certain quarters with "respect to the interposition of the Government. "This growing tendency to commit to the patronage "and tutelage of the Government many of the pur-"suits and enterprises formerly the offspring of pri-"vate enterprise, ought, he did not hesitate to say, to "be watched with great jealousy. (Cheers.) It was "in the growth of individual and local energy, and "in freedom from all artificial and extraneous inter-"ference, that the secret of the greatness of this "country was to be found. That danger of centrali-"zation which had been a formidable and fatal diffi-"culty in other lands had not yet obtained serious "dimensions among ourselves, but it had lifted its "head in this country also, and Englishmen would "show at once their wisdom and their fidelity to the "traditions of their forefathers by taking care not to "hand over to the executive the discharge of func-"tions which would be much better performed by "themselves." Of course it may be said that Mr. Gladstone did not refer here directly to science, but I am not alone in thinking that he had it in view, for immediately there followed an article in the "Times," from which, if you will allow me, I will read a very short passage: "If under such conditions of Government, "the State does nothing for science, it cannot be "helped, nor need it be much lamented, considering "how very little science stands in need of the aid." (I think that bears upon the present inquiry.) "If "the Institution of Civil Engineers had been a crea-"tion of the State, fostered by State counties and "favoured by State protection, its members would "never have acquired such a position in the country "as they justly boast of holding now. As it is they "have fought their way and been the founders of "their own fortune; and so their president has the "pleasure of telling the Prime Minister of the king- "dom that he and his constituents have been and are "independent of all governments whatever." The mistake that I would point out there is, that in the first place civil engineering is not a science, but a trade in the strict acceptation of that word. Engineers are persons who embark their wealth and their time and their minds in an enterprise, having for its object the making of money; I do not object to that at all; but they do not embark in this enterprise for the sake of advancing science, nor do they, I think, increase the advancement of science. On the contrary I think that the tendency of modern engineering, as carried on in England, is to obstruct the introduction of purely scientific ideas. I could give instances of what I state. One is the obstruction that has been offered to the introduction of the Fairlie system of locomotives; it tends to economy, and the leading engineers will not look at it. There is a short line which works that system in North Wales, well known to many persons, the Festiniog line, of 14 miles, which I visited. I asked the engineer of that line, who showed me over it, what three or four leading engineers said when they saw it. "Oh," he said, "they have been asked re- "peatedly to see it, but they will not come, and they "never have seen it." Another example is that of Mr. Fell's system of narrow-gauge railways which is being introduced into foreign countries, but which our engineers will not accept, chiefly, I believe, because it is too cheap.

10,972. Mr. Fell was the originator of the Mont Cenis Railway, but you do not refer to that, do you?—No, this is a separate thing. There are as yet only two lines in England on his plan, one near Furness Abbey of a mile in length.

10,973. But I am told that they could not do the work on it, and that they have been obliged to alter it; it was on the saddle-bag system, was it not?—That was the first attempt and it was abandoned, but it is now in full work and has been for two or three years on another system; the gauge of that line is only 8 inches.

10,974. I believe it is now merely a narrow railway running down from some mines, and have there not been numerous instances of narrow tramways used for the conveyance of minerals from mines?—A little extension of the gauge would suit it for even passenger traffic. A second line on that system is now I believe completed, a short line at Aldershot, and I understand that it is to be very much extended there for the use of the Camp; that line is wider and is to be worked by locomotives. The one that I have alluded to at Furness Abbey, as you may remember, is worked by a stationary engine.

10,975. Do not you underrate the number of narrow tramways used for the conveyance of minerals, are they not very numerous?—Yes, but Mr. Fell wishes to introduce this system on ordinary lines, and to that idea engineers are totally opposed.

10,976. Are there any other matters on which you wish to speak before we proceed with the remainder of your précis?—I should like in the course of my examination to state what I think is the present stage at which science has arrived in this country. What I have to say on the subject is very short, and it illustrates the first part of my evidence. According to my notion there are four stages of progress in science; firstly, the collecting stage; secondly, the observing stage; thirdly, the experimenting stage; and fourthly, the deducing stage. It is the same with nations as with individuals. A child commences by collecting; it collects butterflies, birds' eggs, shells, postage stamps, and generally arranges them without reference to anything but perhaps their beauty, or their colour, or their size. Then comes a little more intelligence and the child observes, for instance, the habits of insects, and the habits of birds and beasts. But very few children, properly so called, perform what deserves to be rated as an experiment. That is generally the work of an adult, and the deducing of general laws from observation and experiment is the work of a mature mind. In my opinion the English as a nation, I do not mean as individuals, but as a nation, are about in the first stage, and they are just entering on the second. We have commenced by collecting in the British Museum, for instance, great quantities of very interesting objects, and we have a certain amount of observing done, but it is not much. There is astronomical observing for instance, but observing of other kinds is very limited indeed. Experimenting, I think I have shown in my evidence, does not exist as a national work. Of course there are individuals who experiment, but the State has not begun experimenting. There is scarcely a purely experimental institution in the kingdom. And of course deduction is a long way off. Therefore, I think that what I have said is no exaggeration, that we are just entering upon the second stage. That is the position of the nation and what we have to deal with.

10,977. I think the objection is sure to be made that if the State were to undertake the conducting of experiments it would check experiments being undertaken by private individuals, what is your opinion as to the value of such an objection?—That objection I have frequently heard made, and my reply to it always has been, first, that I do not believe that that would be so, for the establishment of the Greenwich Observatory has not checked but has rather encouraged astronomical effort in England; and, secondly, if it had that effect we should then substitute a good agency for a bad one.

10,978. Might not some people say that the work done by the State would not be altogether equal to that done by private enterprise?—It might be so said, but I could not hold that opinion myself.

10,979. So far as there are at present any institutions under the management of the State, are you satisfied with the system which is adopted?—No. The chief cause of dissatisfaction is that nearly all these institutions are under different departments, and, therefore, there cannot be that harmony of action which is necessary, with respect to science. The departments, as is well known to all those who have the misfortune to have much to do with them, do not co-operate cordially. It seems to be the nature of departments to act antagonistically to each other. Why I cannot explain; but everybody knows that it is so, and that an amount of jealousy prevails amongst the different departments of the State which is highly injurious to the public service. Therefore, if a particular branch of that public service is divided amongst those different departments it cannot possibly be treated as a whole.

10,980. Have you any recommendations to offer as to the system which you would like to see introduced?—It seems to me that in the first place there should be some means of bringing science fully before the nation through Parliament. I know of no means of doing this that is in accordance with our constitutional procedure, except through a Minister of State, and, therefore, assuming science to be a matter of enormous national importance, I think it is essential that it should be all brought under one Minister of State who should be responsible to Parliament for everything which is done in the name of the nation to further science, and who should frame his own estimates and keep them distinct from those of departments which have little or nothing to do with science. At present the votes for science are to be found scattered through the estimates of various departments; they are in the Civil Estimates, in the Military Estimates, and in the Navy Estimates. Some years ago when I first took up this subject I endeavoured to get at the aggregate amount of money voted annually for science, and I found it quite impossible to do so without personal inquiry. The estimates do not furnish the information; therefore, I think that there should be an estimate for science just as there is an estimate for the army and for the navy. It is a distinct subject, which

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

should be brought under a distinct head of finance, and to do that it would be necessary to have a Minister of State. That is the first of the proposals that I have to make on that subject.

10,981. Would you think it desirable that such a question as the artillery question, upon which you have been speaking, should be entirely removed from the control of the Admiralty or the Ministry of War?—No; the great difficulty in those questions is to bring the professional mind and the scientific mind into contact, and machinery must, I think, be created which would have that object in view. That machinery I shall allude to presently.

10,982. The first essential which you consider should be attended to, is the appointment of a Minister for Science?—Yes. I may say a little more regarding that post. What I should be glad to see would be a Minister for Science, but I daresay that if proper assistance were given to such a minister he might superintend other departments as well; for instance, as on the continent, he might superintend education and the fine arts. I think it would be preferable that he should be for science only. I think there is quite enough for him to do in England, for it to be done thoroughly; but rather than have no minister I would assign to him also education and the fine arts.

10,983. There would be a difficulty, would there not, in defining the boundaries between the duties of the minister for science and the minister for education?—I think not. I think one would relate to education, which is quite a distinct thing from national research, and I think that they should be kept as distinct as possible. I think one great evil now existing is the mixing up of those two things. Throughout my evidence I have here and there expressed the same opinion, that they should be kept distinct, one being the means, the other the end; instruction I conceive to be the mode of growing a certain number of persons fit to investigate.

10,984. What would be the next measure that you would recommend?—The next point would necessarily be some permanent staff for administrative purposes, that is, to say, to conduct the correspondence of the office, to keep up its traditions on changes of ministry, and so on., and that would consist naturally, I should think, of a permanent under secretary with clerks, into which details I need not enter. But the question of the under secretary is one that requires a little attention, for the minister of science might be, for instance, a peer, and I should be very glad if he were so, in which case there would be nobody to represent the department in the House of Commons; and I think that there should be, therefore, a parliamentary under secretary who would not be permanent, but who would speak for the department in the House of Commons, merely following the analogy of the Indian Council and other departments, most of the departments being represented in each house. But there should also be a permanent under secretary to prevent those fluctuations in the mode of procedure which would arise from changes of ministry, and that is the case in the India Office, and other offices too, I daresay. I come now to the third branch of the arrangement which I should recommend. The minister for science would be appointed as ministers usually are, if possible with reference to their qualifications for the post to be occupied by them, but not necessarily so. It is a matter which is so perfectly well known that it is hardly necessary to allude to it. It is an arrangement that many people may be found to extol, and to say it is the best arrangement. Whether it is the best or not, it is inevitable. You must have sometimes, as heads of departments, gentlemen who have not given a special attention to the business conducted by that department. Take, for instance, the present First Lord of the Admiralty, who is a banker by profession. I am not saying that I object to that; but I merely say that it must be so, and that we must accept it, I apprehend, as a thing that will happen, and we must then, I think, guard against the evil that might arise from having a Minister in a post of that kind without proper advisers. And that brings me to the third branch of the department, which is a Consultative Council. I think it has been made apparent of late, that some of the failures (that is the mildest word I can use) which have taken place in the public service, have been caused by the absence of proper scientific advice. Of course I allude to the Admiralty. The great difficulty in reorganising that department, is to provide for the very thing that we are now speaking of, the consultative branch of it. A department of that sort would naturally consist, I think, of four branches; first, the ministerial; secondly, the administrative; thirdly, the executive; and, fourthly, the consultative; but the consultative and the executive are combined usually in one and the same persons. I think that is highly undesirable. I do not think that an executive and a subordinate is a proper person to give advice. He is not sufficiently independent to do so. And I believe that some of the recent misfortunes have arisen from the fact, that the only advisers that the Admiralty has had have been its own subordinates in the executive. And that difficulty would be overcome, as far as it can be, by having a body one of whose chief duties should be to give advice on scientific matters to any department in need of it. Then the department would consist of three instead of four branches; the ministerial, the administrative, and the executive, and the consultative branch would be common to all the departments. That is my idea. If you have a sufficient number of scientific advisers in each department to carry on the business efficiently, the aggregate of the scientific advisers will be very large indeed, and they will not work in harmony. There would be those two objections to the arrangement. That, I believe, has also operated, and the consequence is that the advising section has been totally insufficient; it has been numerically insufficient, and by its very constitution it has been insufficient. I see no way but two of getting over that difficulty; the one is to give each department a further body of independent advisers—persons independent of the ministry of the day, and whose opinions must be recognised to a certain extent, and who are not engaged in executive duties. That is one way of meeting it. The other way is the one that I propose, namely, one body for all. I have thought over both those plans, and I have no hesitation in preferring a general body for the use of all the departments. What I have now said relates to the council as advising the Government in all great scientific problems presented to it for decision. I do not propose that a council of this sort should go into smaller matters, routine questions, but chiefly problems of considerable magnitude. It should be at the discretion of the heads of the departments what questions they should submit to such a council and what they should not. Of course the non-submission of a particular question to the council would saddle the minister of that department with the responsibility for the manner in which the question was dealt with, and, therefore, it would lie with him to decide what questions might be disposed of by his own staff and what questions should be submitted to the council.

10,985. The tendency of most ministers would probably be to avoid responsibility by throwing it upon this council, would it not? It might be so, but I am not afraid of that provided the responsibility is thrown upon competent persons; that is the point I think. At present there is responsibility thrown upon the minister which, in my opinion, is not justly placed upon his shoulders. I think it is unjust to a man to impose upon him duties which he has not the proper agency to execute properly. Of course it may be replied that a gentleman may decline the office; but in that case how would the business of the Queen be carried on? Somebody must hold it, and if you wait until you find a competent man, who is also a parliamentary man, a man of property, and so on, you may wait for ever before you can get him. Therefore, I think, as we at present stand, gentlemen

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

are quite justified in accepting office, but in doing so, they lay themselves under a very grave and unjust amount of responsibility, and of which, so far as science is concerned, I think they should be relieved.

10,986. (*Sir J. P. Kay-Shuttleworth.*) There are matters which are not purely scientific, but in which first of all some scientific question has to be decided, and secondly there is the practical application of that decision in the administration of the department; would you conceive that the consultative council should be so organised as to be capable of deciding such questions independently of the department, or in conjunction with the department?—I should think that it should do both. When I come to the organisation of the council it will be seen that I propose that the professional element of which you now speak should be present in the council, but I should not use the word "decide" at all, but "advise." It should be strictly consultative, and a question might be referred back to it by the department over and over again. The council might deliver too abstract an opinion, an opinion that overlooked certain professional contingencies and requirements, and in that case the department might refer it back and say, "You have over-" looked that one requirement is so and so, and this "will not be met by the abstract opinion which you "have given. You should reconsider it." And in that way the question might be resubmitted by the department as often as it seemed necessary, but there should be in the council a professional representative to prevent the council as much as possible running into too abstracted ideas. When I commenced speaking on this subject, I said that one great object should be to bring the professional mind and the scientific mind together.

10,987. So that practically, taking the two great departments of the service, the army and navy, it would be necessary that in this council there should be persons competent to solve in the way of advice any scientific questions which might be submitted from the army and the navy, and also to appreciate thoroughly the practical application of those questions to the necessities of the service?—Precisely so.

10,988. (*Chairman.*) Are you prepared to give your opinion as to the manner in which this consultative council should be constituted?—I think, perhaps, I had better first say a few words as to their other duties. At present I have spoken of their advising the departments as to their routine business connected with science. They should also advise the minister for science as to the governance of all scientific institutions, because I propose that every State Scientific Institution should be placed, of course, under the Minister of State. He would require an immense deal of assistance in modifying them, or in expanding them as may seem necessary, and in directing them generally; and this advice it would be one of the duties of the council to provide him with. Then another duty which it should perform would be to receive and consider and advise upon inventions. At present that is one of the greatest difficulties that the Government have to deal with. The inventive power of Englishmen is very great indeed, and the departments, I am given to understand, are beset with proposals of new inventions, which are said to be applicable to State purposes, and, at present, I believe that no department has a separate and distinct agency for dealing with this very difficult and laborious question, and the consequence has been great evil to the State, inventions of promise being overlooked in some cases, and very great discontent amongst inventors as to the way in which they are treated. Of course I am quite aware that inventors are a race not easily satisfied, but still we must accept it as a fact that there will be inventions and inventors. We cannot ignore that fact, and the question is whether they should be dealt with in a systematic manner, or, as at present, in a most desultory manner. I would, therefore, make it one of the duties of the council to receive all such inventions. The inventions, if they thought fit, might be first submitted to the department to which they appertained, and by the department forwarded to the council or to the minister of science, and by him referred to the council. Those are matters of detail, but the council should have, as one of its appointed duties, the examination of proposals of this nature. That is another duty of the council; and the fourth would be to conduct or superintend or direct any experiment that might be necessary to enable them to form opinions upon scientific subjects. Naturally, I presume, they would refer experimental work to the institutions which we have been discussing, one of the objects of those institutions being to do work for the Government, and the council should be competent to refer work of that kind to the various institutions. The fifth duty would be the advising of the Minister of State as to assistance to be given to individuals, or to Universities, or to private institutions of any kind, to enable them to carry out given researches. I here allude to the Government grant fund as an example of what I mean; such a fund would naturally be placed under the regulation of this council. Those are the main duties which I think this council should undertake.

10,989. Will you be so good as to state in what manner you would wish the council to be constituted?—On that point I have had very frequent discussions with very competent persons, and although, latterly, I have found more to agree with me, that there should be a council, than was the case when I first proposed it, still many who think with me that there should be a council, do not agree with me as to its constitution or as to its numerical strength; and I had better say a few words upon that point before proceeding to the constitution. I am not aware that anybody has said that a large council will be bad on account of its largeness. I think I have not met with that opinion once, but an opinion has often been expressed to me that a large council will not be granted on account of its cost, which is a totally different opinion; and on that point I should wish to say this, that I came before this Commission intending not to state what I thought the Government would be likely to grant, but to state what I thought the Government ought to grant. If I had limited myself to what I had been told by persons more or less well informed it was likely that the Government would concede to science, I should have troubled the Commission much less than I have done. In fact, I should hardly have been able to make any recommendation at all; for I have been told over and over again that such things as great laboratories will not be allowed, but are out of the question; that there are principles of economy now working in the Government which are totally opposed to such an idea; in fact, that it is madness to think of it. But that does not deter me from saying that it ought to be done. And in the same way with respect to the council, I wish to lay before the Commission what I think that council ought to be, not what some persons tell me it may be. The chief objection, indeed the only objection, that has been made to me against a large council is its cost. I wish to say that I consider that a purely secondary matter. If my idea of the importance of science to the State, and of the greatly impoverished condition of science in England, is correct, then a matter of 20,000*l.*, 30,000*l.*, 40,000*l.*, 50,000*l.*, or 100,000*l.* a year is a mere bagatelle, compared with the enormous interests involved. Therefore, I utterly refuse to consider the matter of expense. I look upon it that money spent in this way is money invested; it is not money sunk at all. If it is considered as money sunk, there would hardly be any discussion on the matter; but it is money invested, and I suppose that there are very few people who do not prefer large investments to small ones, if they are good. On those grounds I would beg leave to lay before the Commission the constitution of the Council such as I think it ought to be.

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

Sketch of proposed Council.

Pure Mathematician (the Professor of Mathematics at Oxford and Cambridge alternately. These should be "Regius Professorships")	1
Mixed Do. (Astronomer Royal for the time being)	1
Chemists (one to be the Director of the proposed Chemical Laboratory)	2
Meteorologist (Director of Meteorological Department)	1
Physical Astronomer (Director of proposed Physical Observatory)	1
Metallurgist (Director of proposed Metallurgical Laboratory)	1
Geologist (Director of Geological Survey)	1
Physicists (one to be an Electrician)	2
Naturalist (Head of Natural History Department of the British Museum)	1
Physician (Medical Officer of the Privy Council)	1
Surgeon	1
Physiologist	1
Naval Architect	1
Civil Engineer	1
Mechanical Do.	1
Mining Do.	1
Statist	1
Royal Engineer Officers	2
Royal Artillery Do. (one for Field Artillery, the other for heavy Ordnance)	2
Royal Navy Do. (one for Navigation, the other for Gunnery)	2
Infantry Officers	2
Merchants (one a ship owner)	2
Agriculturist	1
Total	30

Of course I give that sketch of the council as a mere indication of the sort of council that I think is desirable. It is something that I put before the Commission in order to be torn to pieces and put into shape; it is a mere sketch of a possible council. I have given it a great deal of thought, and it does not appear to me that there are any superfluous members in it, nor do I know of any that have been omitted. I may say generally that one of my great objects was to place in this council the heads of institutions, in order that they might be concerned in the directions given to their various institutions. I think it would hardly do (in a former part of my evidence this matter was alluded to) to have a separate body directing men of eminence as heads of institutions; it would be felt to be an interference, but if those heads were part of the governing body, then the interference would not be felt.

10,990. What would you say to the Director-General of the Army Medical Department and of the Naval Medical Department being members of the council?—I think these are all details which would have to be very carefully considered when the council was drawn up. It is all in accordance with the principle which I have endeavoured to keep in view here of giving the heads of departments a share in the direction, as it were, of their own departments.

10,991. They would supply the practical knowledge that was necessary?—Yes.

10,992. (*Professor Huxley.*) Would it not be desirable to have somebody else representing the different departments of science, apart from the official people?—Yes. That swells the council again, and that is one of the insuperable objections to a small council; and, supposing that you were to have six, you cannot have the whole six heads of departments, leaving out, perhaps, six or eight who are not heads of departments, and you cannot select from those one or two; you must have them all.

10,993. (*Chairman.*) How would you propose that these members should be appointed who have not seats *ex officio*?—I should recommend them to be appointed in the same way as the heads of departments should be appointed; in this manner—first, the scientific society, which dealt with the particular branch of science in question, should be called upon to name four persons qualified for the post; whether the post was that of the head of an institution such as an observatory, or whether an independent member of the Council; that those four names should then be submitted to the Council itself and be reduced to two, and that those two names should then be laid before the Secretary of State, who should select one of them. That is a mode of election that occurred to me after thinking it over a great deal; and since I put it forward in my printed paper on "The necessity for a permanent Commission on State scientific questions,"* I have heard it discussed, and I have not heard any objection taken to it. On the contrary I have generally been told that it seems a good way of providing for it. The objects that I had in view were these: first, that the appointment should be one quite independent of political influences; I look upon that as an essential; secondly, that a competent constituency should have a voice in the election; and thirdly, that the council itself, as being interested in the efficiency of its own body, should also influence the election; and according to this scheme, which I now put before the Commission, those three objects are attempted to be met.

10,994. What salaries would you propose that the members of the council should receive?—I should propose the directors of institutions and the naval and military officers, as they are *ex-officio* members, should receive 500*l.* a year, in addition to their other salaries, and the other members of the council 1,500*l.* a year each.

10,995. Do you think that a large staff would be required in addition?—Yes, I presume so. It is very difficult beforehand to say what would be necessary. It would be a department which no doubt would grow rather rapidly; but of course there would have to be a secretary to the council, with clerks and a legal adviser. They would have the whole use of all the State scientific institutions for their experiments, and therefore that would not be a separate charge; their staff, therefore, would be chiefly administrative, and not executive.

10,996. (*Dr. Sharpey.*) What is the payment of a member of the India Council?—I think it is 1,200*l.* He is generally a retired officer, either military or civil, with a handsome pension; and that is an office I may say, without any disrespect, for which you would find hundreds of competent persons, which is not the case with science; there are very few competent scientific persons.

10,997. (*Professor Smith.*) Would you propose that those appointments should be for life?—I do not see how it can be otherwise. I do not see how it would do to appoint persons to such posts for a limited period. That is the only other solution that there is, in fact, and I do not see how you could appoint a person for a limited period to a great laboratory or a great observatory, which would constitute him a member of the council. For instance, to change the Astronomer Royal every five years would upset the world.

10,998. My question had reference more particularly to the non-official members of the council?—I should make no difference with respect to them, and on this reason that the duties that they will have to perform will be of a nature that would not be easily acquired, and those duties could not be performed by inexperienced persons. I think, however eminent the persons that were first appointed, the council could not be as efficient at first as they would be after a few years, and that when they had become trained to the duties, to dispense with them would be really to injure the public service most materially. But I am quite aware of the difficulty involved in this question, that is to say, the difficulty of getting rid of inefficient men, for that is the real object of a limited service; it enables the Government to get rid of a person that they do not quite like, without, so to speak, damning him for life. That is the main object of the five years' system

---

* Read at the Royal United Service Institution, 15th May 1871.

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

as applied to some military appointments and others, but the true guarantee against the evil of life appointments consists in the care with which they are made. You must have a well-considered mode of appointing them, a mode such as will, probably (for after all these matters are mere matters of probability, there is no certainty in them), obtain for you the best men, and then you must make the best of them.

10,999. (*Sir J. P. Kay-Shuttleworth.*) Have you thought of any system of superannuation after a considerable number of years of service, to be given at an advanced age?—I hardly like that either, because the duties are those which I think men of advanced age will perform sometimes even better than young men.

11,000. Not necessarily to be taken at an advanced age, but to be available supposing that strength and health should decline?—Then, I think, if they are conscientious men, if they are men who should have been appointed to the council, they would retire. I know, however, that people do not always see it in that light.

11,001. (*Dr. Sharpey.*) Would not one difficulty of a limited appointment be that you would be taking men from their own private pursuits by which they earned their livelihood, and it would not do to throw them back again when perhaps they could not resume those pursuits?—No, they could not resume their career. I know that it is a difficulty which has been mentioned to me frequently, and I see no way of getting over it but by observing the greatest care in the appointment of the members of the council; and as to the superannuation scheme, it would operate beneficially in some cases and the reverse in others. There are some men who are superannuated at 60, and other men whose intellects are as vigorous as ever at 80.

11,002. (*Sir J. P. Kay-Shuttleworth.*) A superannuation scheme might be devised which would not render it compulsory upon anybody to retire at any given age, but might make it optional and, perhaps, a matter of conscience with him to avail himself of some mode of retirement which might be open to him?—If you mean that there should be a pension available after a certain service, I think that that certainly is a desirable condition.

11,003. Available to any man who, on conscientious grounds, might desire to retire from the service finding his health, his power of application, or even his faculties declining?—Yes, I think that would be very valuable certainly.

11,004. (*Professor Huxley.*) There is one difficulty in your suggestions to the practical carrying of them out. I apprehend that you propose to put a very considerable amount of work upon the members of this council? Yes, a very considerable amount.

11,005. Under those circumstances it would be quite impossible for a man of scientific eminence, who should be a member of this council, to devote himself as he had done heretofore to original inquiry?—Yes.

11,006. Do not you think that that would operate very largely as a bar to the coming of the best men, the very men whom you want to get on to this council. And do not you think that there would be then a very great danger of having the post filled by second and third rate men who would intrigue for it?—I think there is that danger. I think that that is one of the great difficulties of the whole thing, and I have endeavoured to meet it by putting the salaries at a higher figure than anybody with whom I have consulted on the subject has put them. Everybody has told me " Your salaries are absurd;" but precisely for the reason that Professor Huxley has hinted at, I have put them at that high rate, in order that a man of great eminence in science might not be induced to give up the best part of his life, which he would have to do, to work of this sort, unless he were properly remunerated; and whether even 1,500*l.* a year would tempt the best man I cannot tell you beforehand. If it does not, you ought to double it.

11,007. Do not you think that the best men are exactly those whom you could not get for double or treble that amount. Take the case of the late Mr. Faraday, for example. If you had offered him 10,000*l.* a year, I do not believe he would have taken one of those posts?—Possibly he individually might not, but I think that the position which it would give to anybody, however eminent, and the influence and the power of advancing science are all elements that would tempt a man even in affluent circumstances to accept the post, just in the same way as the membership of Parliament, which is without any remuneration at all, tempts men of great wealth to devote their whole lives to the public service.

11,008. I am not speaking of men of great wealth, but of thoroughly good and valuable men irrespective of their wealth; and I take as a case the late Mr. Faraday, who certainly would not have given up his time, and the power of devoting his time to original research, for any income that you could have offered him?—In that case you would have to lose him.

11,009. Then is there not standing before you the great danger to which I refer, that the men who will fill those posts will be busy men, men to whom the emoluments, the position, and the vanities of the thing are worth a good deal, and probably not men whom you want to have there?—I think that the same difficulty applies to filling up at present scientific posts under Government, and it is not found to act at all in that way. For instance, take the Astronomer Royal—he is a man of the very highest eminence, who is quite willing to devote his whole life to astronomy in the service of the State, and I think that you will generally find that there will be men who will be willing to do so.

11,010. In the case of the Astronomer Royal, the Astronomer Royal devotes his time to astronomy in the service of the State, but in the case that you are now speaking of, the members of that council must devote their time to administrative work, and not to the promotion of any branch of science, which makes all the difference. I apprehend that a member of this council will really have to give up his time to it exactly as a member of an ordinary department of the Government would have to do?—That is my idea certainly.

11,011. So that he would have to sacrifice his scientific work?—Yes, to some extent.

11,012. (*Chairman.*) If that is the case, how would the Astronomer Royal and other directors of institutions find time to attend to their duties as members of the council?—I think that that will be brought about by a sub-division of the council into committees, and that they will have to attend to matters connected with their own particular departments.

11,013. You think that some members of the council would not have their time so fully occupied as to prevent their attending to their duties as heads of institutions?—I should think so in practice, but it comes round to this, that at present we are without anything of the kind, and we must do our best. As for attaining perfection in the matter, of course there is not the slightest hope of it.

11,014. Might not an objection be made to this proposed council that although each individual member might be a most competent man to give advice on his own subject, yet, as a whole, the body would not be perhaps the best from which to obtain advice on any particular scientific question. For instance, on the question of geology, we will assume that the geologist is the best in the country; but would the council, as a whole, be the most competent body to give advice upon such a question?—The way in which I should imagine the business of the council would be transacted I think answers that question. I should propose that the council should sub-divide itself into committees, either standing committees or committees temporarily appointed, that those committees should examine the subjects submitted to them, say a given subject—geology, as your Grace remarked, they should then report to the council, and the council should deliberate on their report. That would be rather different from the council investigating the subject itself. It would have

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

brought before it the opinions of colleagues who were versed in the particular subject, with all the reasons for those opinions, and I think that if they were men accustomed to scientific investigations generally, they would be quite able to say whether the report was a judicious one or not, and they would then have to adopt it as their own. Therefore, I should propose that every advice given by the council should be given by the council as a whole.

11,015. (*Sir J. P. Kay-Shuttleworth.*) Supposing that you had a council consisting of a much smaller number of very highly instructed men of science, each probably more distinguished in some particular branch than the rest of his colleagues, and that you associated with them (not necessarily as members of the council) the heads of the several departments which are enumerated in your proposed council, those which are to be constituted according to your proposal, as well as those which exist, and that this scientific consultative body should refer for reports to the several subordinate departments, and then give advice upon such reports to the department, do you not think that some of the difficulties arising out of the proposed constitution of the council would be avoided?—Schemes very similar to that have been mentioned to me as feasible, but I do not think that such a scheme would work as well as that which I have submitted; if for no other reason, on account of the one which I have already alluded to, namely, that according to that scheme the heads of the departments would not be members of the council from whom they receive instructions. I look upon it as very essential that there should be no antagonism between the heads of institutions and the council.

11,016. Might not the head of each particular institution, in any question affecting his institution, become a member of the council for the time being?—That might be done, but I do not think that as a temporary member of the council taking his seat to investigate a particular question he would have the same weight as if he were a permanent member. I do not think that that would work so well.

11,017. Having regard to the formidable difficulties which will necessarily be encountered before any scheme is accepted by the Government, and to the importance of proceeding upon the principles which you have advocated, might not a council constituted of the very highest scientific authorities of varied qualifications be regarded as a very important first step towards the accomplishment of the object which you have in view?—I should consider it a very important first step, and supposing that step were taken, I should feel convinced in my own mind that a further step would very soon be taken, namely to make the Council complete.

11,018. With regard to the creation of a consultative council, say of half a dozen pre-eminent qualified scientific men, with varied qualifications, that would be an exceedingly important first step?—Most decidedly. I have put before the Commission, as I said before, not what I think is probable, but what I think should be; but I have no hesitation in saying that a council such as has been indicated would do an enormous deal of good to science, and put science in quite a different position.

11,019. (*Dr. Sharpey.*) I presume you contemplate that questions would arise in which it would be desirable, if not needful, to obtain opinions and advice through members of the council from persons not actually on the council?—Yes, certainly.

11,020. If that is liable to happen, with even a large council, could it not be the mode followed in the case of a small council, such as Sir James Kay-Shuttleworth has suggested, that very competent men, men of science, men of judgment, who are informed in science generally, could in particular cases obtain the opinions of persons specially skilled in a particular branch when they were wanted, and the members of such a council would be highly capable of judging upon the expediency of adopting that advice, would they not?—Yes.

11,021. If that is liable to happen with a large council, might not a smaller council answer the same purpose?—I think not. That idea has frequently occurred to me also; and as you have remarked with even the largest council, with treble or quadruple the number that I have assigned to it, it will be necessary occasionally for them to call in outside persons and take evidence and so on, and examine persons outside the council. I should be very sorry indeed to so order matters as to exclude their doing that; but the council, as I have sketched it here, is a truly representative council. If it were a council say of six, I should consider that a small council; anything more than that would rather tend to be a large council; perhaps a council of six might be put against my council of 30, but a council of six, I think, composed of men, however eminent, would not be a representative council; and therefore I think that they would be obliged to have recourse to so very great an extent to outside opinion as really to throw the responsibility upon persons outside the council, and so perpetuate what I think is the great evil of the present time, that temporary bodies, committees, and so on, are formed to advise the Government on particular questions; and the responsibility attaching to them is very undefined indeed.

11,022. I should not contemplate their referring the matter to a committee of outside persons, but that they should communicate with and consult the best informed men, though not in the council, upon the particular question at issue, and that they themselves, as a council, should then give their opinion and be responsible for it?—But still it would not always go back even then; although they were officially responsible, they would always be able to say, Well, we took the best advice we could get; we consulted Mr. So-and-so and Mr. So-and-so, and that at once diffuses the responsibility.

11,023. But would that objection be obviated by means of a larger council?—I think so, to a very great extent.

11,024. Still, if you take a particular case, we will say a question in metallurgy, it would remain with the metallurgist, or the one or two metallurgists on the council to advise the rest?—There would be chemists also, and physicists, and mathematicians, all of whom would bring their knowledge to bear upon the question. I think that the council should be representative, but rather than have no council I would willingly see one appointed, such as Sir James Kay-Shuttleworth has indicated, a small council, but I think that it would be soon found to work inconveniently. It would work in this way, that all their inquiries were made really by persons unknown to the public, or scarcely known.

11,025. I presume that the council would report whom they had consulted?—Yes.

11,026. (*Sir J. P. Kay-Shuttleworth.*) As respects the sense of responsibility is there not this fact, that a small body consulting after having made any kind of inquiries they might think fit would probably feel that responsibility individually in its members more than a larger body?—Yes, I think that that is so, no doubt, and it becomes in that way a question of balancing advantages and disadvantages. I can only give my own impression that the preponderance of advantage seems to me to be in favour of what I call not a large council for the sake of largeness, but a fairly representative council.

11,027. (*Professor Smith.*) How do you think that this council would deal practically with such a question as that which you were mentioning earlier in your evidence, the constitution of iron for the purposes of ordnance; if such a question were submitted to it, in what mode exactly would it deal with it? That is a question which I presume as long as the world lasts will be worked at. I presume there never will be an end to the examination of metals, and therefore I believe that that will be one of the regular routine works to be undertaken by one or other or several of the laboratories. It will be always going on. I think it is not a special problem that could be submitted to a general body of men, and solved, and disposed of, but

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

there will be work of that sort always going on as long as the world lasts.

11,028. Would not the whole time of your metallurgist be absorbed in that sort of research?—No. His work would be that of superintendence. He would have under him very skilled men, men, some of them nearly as highly distinguished as himself, and he would assign to each his particular work, and his own duty would be general superintendence.

11,029. So that practically that would be the principal part of the duty of such a member of the council? —I think so. I have very frequently been asked what definite duties would you assign, say to this laboratory, and it is always a difficult question to answer, because you can never see what the tendency of scientific investigation may be; but with regard to the metallurgical laboratory there is no such difficulty. The metals should be taken up seriatim according to their economic importance, and they should undergo constant examination, which I believe would never end.

11,030. Supposing a particular question should arise about iron, for instance, requiring an immediate or an early answer, what would be done?—It would be submitted by the council to the metallurgical laboratory, and such problem put into a definite form would come before the council and be discussed by all as to the best mode of performing the experiment, the work would be assigned to the metallurgical laboratory or to the physical laboratory, as the case might be, in consultation of course with its head. He would express his views, and no doubt they would have great weight.

11,031. Do you think that men of the high scientific attainment that you would suppose those assistants to be would really work as well at subjects given to them by order, as they would at subjects chosen by themselves; that a man, for instance, would devote so many years of his life simply to such an inquiry as you have mentioned?—That is speculating on human nature. Some men would and some men would not. But I quite see the drift of the question. That if there are men of high originality and great genius, they are very often better left to themselves, and it is so no doubt; but still public business cannot always conform itself to the peculiarities of individuals. They would have to be directed and have to do as they were told, just as the assistants at the Greenwich Observatory have to make observations of particular stars in a particular manner, according to a particular system, and reduce them in a particular manner, every step in the process being laid down with the most absolute unbending rule.

11,032. But the determination of the unknown properties of metals cannot be compared to observations which you can give precise rules for making?—I apprehend that a judicious head of such an establishment would in the first place endeavour to have very qualified men under him, and he would then shackle them as little as possible. He would say, Now, Mr. So-and-so, here is a particular property of iron which wants investigating: how do you think of setting to work at it? And he would assist him rather than direct him. I think that that is the way in which a judicious head would manage those matters.

11,033. (*Chairman.*) Are there any other observations which you think it desirable to lay before the Commission with respect to this proposed council?—I have inserted in my précis, in page 13, a quotation from a note by the late Professor Baden Powell, in his translation of Arago's "Eloge on Dr. Young." It is a very decided opinion given by a very eminent man, now no more, in favour of the very sort of council that I am now advocating. With reference to the Board of Longitude, Mr. Baden Powell remarks, "that board " was divided against itself and it therefore fell. It " was never upheld on the only right ground. Neither " the board nor the friends of science sufficiently urged " the strong and irresistible claims which they might " have preferred to the Government of the country " That a *Council of Science, with extended powers,* " *properly selected, and adequately remunerated,* " would be the appropriate adjunct of the Government " of a country, all of whose resources are so powerfully " developed in exclusive dependence on the applica- " tions of science. The Government would thus have " had the means of sound scientific advice constantly " at hand, of which experience proves they are in " daily want on every emergency, and which they " obtained by asking the gratuitous services of men " of science, and the Crown would have possessed the " means of making a graceful acknowledgment of " the services, and paying a just tribute to the genius " of men devoted to the higher branches of the " abstract sciences which are of a nature incapable of " themselves of affording any kind of remuneration, or " in the ordinary course leading to any of those honors " or preferments which await eminence in other " professions."

11,034. Do you know anything of the constitution and the history of the fall of the Board of Longitude? —I can give no explicit account of it. Since meeting with Professor Baden Powell's remarks, I have endeavoured to obtain the Parliamentary papers relating to the subject, but am told they are out of print.

11,035. Have you thought how far the objects which you have in view in proposing this council would be accomplished by the establishment of a paid academy as in France?—I do not think that the duties of paid academies, as far as I know them, have the same scope as those which I should assign to the council. I think that their scope is far more limited.

11,036. You would not recommend a paid academy? —No; I wish to see such a body with the most extended possible duties; and the principle of an academy is too restricted I think.

11,037. (*Sir J. P. Kay-Shuttleworth.*)—You distinguish probably between a consultative council, which you propose should be the adviser of the Government on scientific questions, and an academy which, wherever it has existed, has had almost controlling power over science by distributing honours, and which, therefore, would be liable to certain objections on the part of men of science, who would not like to submit themselves to any such controlling power? —Precisely. And it must always be remembered too, I think, that in foreign countries there does not exist what there does in England. We have certainly an advantage over all continental nations in respect to the great strength of our private societies. That is an element which is almost absent, I think, in foreign countries, and it is one that is particularly strong here, and particularly valuable. And probably the absence of such societies constituted one ground for the creation of an academy. The academy in some measure performs the functions now performed by our chief scientific societies which you have just alluded to—the distribution of honours and so on; but I do not anticipate that the consultative council should have to do that at all. I do not myself attach very great importance to prizes. I think that all that would be done quite sufficiently by our private societies. The Commission will have perceived that I have almost studiously avoided quoting foreign systems as being models for our system. I think, on the contrary, that we should create a model for them, and I think we have it in our power to do so. We have a clear field before us, and we have it in our power to create a far more complete system than any which exists on the continent, and in a great measure because we have our scientific societies, which are a sort of foundation to the whole. I would make these the constituencies—the means by which members of the council are elected All that gives us a great advantage, and therefore I think we are in a position in England to create a far better system than any that exists abroad, and for that reason I have not quoted foreign systems.

11,038. (*Chairman.*) Do you know whether the French government are in the habit of submitting such questions as that of which mention has been made more than once, as to the properties of iron, and so on, to the French Academy?—So I have understood, but only in a sort of desultory and accidental manner. If such questions were systematically submitted to the

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

academy I apprehend that the members of the academy could not do the work. It would entirely alter the constitution of the body, who are not constituted for such work.

11,039. Is it your opinion that much good can be done by the grants of money?—Yes, I think that great good has been done, and great good can still be done by such means. There are great numbers of persons in England who are very competent indeed to advance scientific knowledge, and very willing to devote themselves heart and soul to that object, but who cannot do so for want of means, and I think that it is highly desirable that such persons should be encouraged to the greatest extent possible, and therefore I think that grants of money are one of the most valuable modes in which the State can assist science. And I should also include institutions. I would not restrict those grants to individuals, but private institutions might also be assisted with great advantage.

11,040. Do you consider the 1,000*l.* grant to the Royal Society inadequate for the purpose?—I can only say that I think it is a downright absurdity (I can use no other language) to suppose that in a nation like England 1,000*l.* distributed yearly can produce any material effect upon science. That it produces some effect of course is undoubted. You cannot spend any money at all upon science honestly without producing some good effect; but that a great nation like England should be satisfied with the distribution of 1,000*l.* for encouraging individual research seems to me nothing short of absurdity.

11,041. Have you formed any idea in your own mind as to what amount it would be desirable to appropriate for the purpose, or would you have it a variable sum?—I think it should be variable; as opportunities for spending money in that way occur the Government should avail themselves of such opportunities, but perhaps it would be considered unbusinesslike to say that an unlimited sum should be spent annually. I should certainly think that 10,000*l.* a year might be spent without the smallest fear of extravagance, and with the certainty of the most important return, because the distribution of a comparatively large sum like that will be the means of facilitating, not so much a greater number of investigations, but a different class of investigations altogether; a class of investigations which now cannot be undertaken by the small grants which annually are available. Therefore, if pressed to name a sum, I should say that 10,000*l.* certainly might, without any fear, be assigned to that purpose. But here comes in the advantage of something like a system for the government of science; that is a question which would arise with each estimate. As the Minister of Science presented his estimate he might be able to show that the grant last year was insufficient, and that he had assigned 20,000*l.* for the next year. Of course the matter would be debated in Parliament, but at present, because there is nobody to settle these questions, they are settled once for all, and they are settled at a given period, and then each successive administration accepts them as its fate. There is no power of altering because there is nobody to go to. There is literally in our Government nobody to go to with the hope of making it clear and intelligible to him that this grant is insufficient. I say that most advisedly, as having come to my knowledge in connexion with applications to the Government for aid in the eclipse expeditions. I have been a member of several committees recently on that subject, and one of the great difficulties has always been that we did not know whom to apply to; there was really no member of the Government whose business it was to entertain an application of that sort. And, accordingly, on one occasion the application was first sent to the Admiralty, who sent back a very laconic reply indeed, to say that they had no means at all for such purpose; they could only talk about ships. Then it was sent on to the Treasury, where it was misunderstood. There was nobody there who knew anything about science, and the thing was totally misunderstood, and it would have fallen through but for the enterprise of an individual who was fortunate enough to get the ear of the Chancellor of the Exchequer, and persuaded him to make a grant, which it was not his duty to do at all; it is no part of the duty of the Chancellor of the Exchequer to make grants of money, it is his duty to prevent grants of money being made. That expedition very nearly failed altogether, not because of the unwillingness of the Government to assist, but because there was literally no member of the Government to whom to make the application. And so with reference to this Government grant which is now made; if the Royal Society felt disposed to favour the idea of a larger grant they would not know whom to turn to; they would make application, no doubt, to the Prime Minister, and we know what use it would be to make an application of that sort. In saying this my intention is not to blame anybody, but it is obvious that gentlemen who are engaged in politics have not time to devote to science.

11,042. (*Dr. Sharpey.*) Do not you think it would be fair to note that that grant of 1,000*l.* was a spontaneous offer from the Prime Minister of the day?—I believe it was. I was informed by the late President of the Royal Society, Sir Edward Sabine, that Lord Palmerston had told him that if the Royal Society only said so, the grant should be made 10,000*l.* I remember Sir Edward Sabine telling me that, and I remember my reply. I said that I thought he had a great deal to answer for in not having asked for it.

11,043. If any particular objects should arise requiring a larger grant, you would be prepared to recommend it?—Yes.

11,044. (*Sir J. P. Kay-Shuttleworth.*) Can you, of your own knowledge, as a member of the committee of Distribution of the Royal Society, state whether in the administration of that grant, it has been given chiefly for abstract scientific investigation or not?—As far as I know the regulations relating to the grant there are no limitations. I think it rests entirely with the discretion of the committee who should receive the grants, and they are available not only to the fellows of the Royal Society, as some suppose, but to the whole country. Any person whatever is entitled to make application for a portion of that money, and his application will, as a matter of necessity, be submitted to the committee, and there it is always discussed with very great care, and possibly referred back to the applicant for further information, and so on. But the kind of research is not defined in any way; it is given for every variety of scientific work. If you will allow me to amplify my answer to your question it might be as well to place upon record that the committee consists of 42 persons. 21 are members of the council. The Council of the Royal Society are *ex-officio* members of that committee, and the other moiety are fellows of the Royal Society elected, I am not quite sure by what process, probably by the council, so that there are 42 men, many of them of very great distinction in science, who are occupied in distributing 1,000*l.* a year. And I must say this, that I have continued to act as a member of that committee, because I would not withhold any little help that I could give to science in whatever way it could be given, but I have never left the committee room without feeling that I have been engaged in the performance of a ridiculous farce. There is no other language that I can use with propriety. It is a ridiculous farce that a body like that (I have frequently seen 30 and odd members present) should be there discussing for hours together the distribution of such a sum as 300*l.* or 400*l.*, for I may mention that the whole grant is not brought under discussion at once. When a certain number of applications have been made, the secretary in his discretion calls a committee, and sometimes the amount to be distributed is not more than about 300*l.* or 400*l.*, and for thirty odd eminent men to be occupied for a whole afternoon in distributing such a sum of money as that, I can only say what I have said, is preposterous.

11,045. (*Dr. Sharpey.*) It might be useful to have your opinion as to the reason why the applications for

Lieut.-Col. A. Strange, F.R.S.

8 May 1872.

appropriations from the Government grant are not more extensive?—I believe it is quite true, and I think that is what Dr. Sharpey's question points to, that sometimes the whole 1,000*l.* has not been distributed. I can only explain it by supposing that scientific investigation now has arrived at such a point that really it cannot be pursued by means of small sums of money. I believe that that is the true explanation, for I remember an objection which was made to me when I first began considering these various questions. The objection was made, "Why, what nonsense it must be "to ask the Government for laboratories in which to "perform scientific experiments when you cannot "spend 1,000*l.* a year upon them!" But it seems to me that that argument tends quite the other way, that 1,000*l.* a year is not a sufficient provision for that work which could be done only in great establishments.

11,046. In such a case as that of the observation of the eclipse, a very much larger sum was required than was placed at the disposal of the Government Grant Committee?—Yes, of course. It would have absorbed two or three years of the Government grant.

11,047. (*Chairman.*) Would you propose to entrust the distribution of any sum of money, whatever it may be, that was voted by the Government, to this consultative council, supposing it to be established?—Yes. My idea is that this duty which is now performed gratuitously by the Royal Society, and I must say is performed according to my humble judgment most admirably and conscientiously, is a duty which should devolve upon the council.

11,048. Unless such a council was established you could not suggest any improvement in the present arrangement with regard to distribution?—No, certainly not. It could not, as matters now stand, be in better hands than those of the Royal Society.

11,049. (*Professor Smith.*) Would you propose, in increasing the amount of the grant, to widen in any way the purposes to which it is applied, because at present no part of the personal expenses of any person who receives the grant are paid?—No, they are not.

11,050. Would you propose that that should continue?—I think that the utmost liberality should be displayed in such matters. I should wish to augment it where it seemed necessary and where the object seemed to deserve it. Of course with so small a grant it is out of the question to do that, but I should certainly wish to see that done. To take the very example which has just been alluded to by Dr. Sharpey, that of eclipse expeditions, there was a great difficulty last year in equipping and organising the expedition to India, and great difficulty in finding persons willing to go, because the sum of money provided by the Government was barely sufficient; in fact I believe it was insufficient to cover the expenses of the voyage out, the cost of the instruments and the unavoidable general expenses, but the personal expenses of the persons who went out had to be defrayed by themselves. There were many men who would have done most excellent service, but who really could not afford, in the first place, to neglect their business at home for several months, and in the next place to go out and incur considerable expense in India for the public good. They were then in the performance of what I conceive to be a national work, and they did it at their own expense. But I do not think that that is a right state of things; and the question which I have just been asked bears upon that very point.

11,051. (*Chairman.*) Do you think it possible that if grants of money were given to a considerably greater extent, they might possibly supersede the necessity of your other recommendations as to the establishment of new Government institutions?—I think not. I think that both descriptions of agency will require to be employed. The routine strength which is obtained by a permanent establishment would be one thing tending in one direction, and the occasional energy of individuals would be quite a different thing, and both should be encouraged. I do not think that they would modify each other at all, but that they would help each other.

11,052. Are there any other additions which you would wish to make to your evidence?—At this moment nothing else occurs to me.

The witness withdrew.

EDWARD FRANKLAND, Esq., Ph.D., D.C.L., F.R.S., further examined.

E. Frankland, Esq., Ph.D., F.R.S.

11,053. (*Chairman.*) On a former occasion you stated, did you not, to the Commission that scientific research has made much more progress in France and Germany that in this county?—Yes, I did. I gave some statistics at that time bearing upon the subject with regard to Chemistry, showing that chemical research progresses more rapidly both in France and in Germany than in this country, and perhaps I may be allowed to add now some further statistics which I have collected recently in reference to the comparative energy of chemical research in Germany and in England, as illustrated by the papers communicated to the English Chemical Society on the one hand, and to the German Chemical Society on the other. The English Chemical Society has been in existence for 31 years, but in no single year during that time has it received more than 54 original papers, whilst the German Chemical Society received in the year 1870, 235 original papers, and in the year 1871, 258.

11,054. (*Dr. Sharpey.*) Which society are you referring to?—The Berlin society.

11,055. (*Chairman.*) Is that considered to embrace the whole of Germany?—Yes, there are members of it distributed all over Germany.

11,056. Would you say that on the average each of those papers was of equal importance and equal value?—That I could not say.

11,057. I mean are they in the habit of communicating papers on matters of less importance in Germany than in England?—I should think not. I should say the reverse, but I would not pledge myself to the absolute accuracy of such a statement. A great number of those papers communicated to the German Chemical Society were papers of very considerable importance.

11,058. (*Professor Smith.*) But were there not a good number of smaller communications among them?—Yes, there were, but this was the case in both countries. No doubt the majority of the papers would be put under that category.

11,059. (*Dr. Sharpey.*) Are chemical papers communicated to the Academy of Sciences at Berlin?—Yes.

11,060. That would be independent altogether of those of which you have been speaking?—Yes, independent of those certainly

11,061. And so in making a comparison you would also exclude from the English papers those that were communicated to the Royal Society?—Yes, in the comparison I take no notice of the papers to the Royal Society, but they certainly would not be more numerous than those communicated to the different German Academies, such as the Berlin and Munich Academies, and several other similar scientific bodies.

11,062. (*Chairman.*) It would not be stating your opinion too strongly, I presume, to say that you consider research to be very languid in England?—Yes, taking the results of these statistics as well as my own observation in the matter, I cannot but conclude that research is at present progressing very languidly in this country, and has done so for many years past. We have various modes devised ostensibly for the advancement of science in this country, which are progressing with more or less activity; for instance, we have the instruction of the public in practical and theoretical science. We have public lectures, such as those given at the Royal Institution, which are admirably qualified for exciting an interest in science in the public generally. The same thing is also going on in the

E. Frankland, Esq., Ph.D., F.R.S.

8 May 1872.

writing of articles for periodicals, and we have also a display in museums, and exhibitions of various objects of scientific interest. And lastly we have a continually increasing number of handbooks, cyclopædias, and treatises upon science, written in this country; many of these methods are very active and are progressing satisfactorily. But, in my opinion, they are only accessories to the real advancement of science; they are of great importance, and very necessary to instruction in science, but still all these methods may be in the most perfect operation without any advancement of science at all. In fact it may be stated broadly that all those operations may be going on in the greatest perfection, but if something is not superadded to them, science will certainly stand absolutely still and not advance at all, and that something which requires to be added is, I need hardly say, original research.

11,063. You think that there can be no real advancement of science without original research?—No, there cannot.

11,064. Can you make any suggestions as to the stimulating of original research in this country?—I have already, upon one of the former occasions when I was examined by this Commission, mentioned some facts in connexion with that question, namely, the necessity, as I conceive, for making original research enter into the requirements necessary for the taking of the highest degrees in science in this country. And this, so far as teachers of science in this country are concerned, is at the present moment a matter of the most urgent importance, in order to secure greater activity in research. But we have in this country a considerable body of investigators who are not engaged in teaching at all, and I think that this is a peculiarly hopeful feature of our case. It shows that the English have not only a taste for research, but that they have a natural talent for it. We have numerous men like Mr. Gassiot, Sir W. Grove, Mr. De La Rue, Mr. Spottiswoode, Mr. Huggins, Mr. Dappa, Mr. Buckton, Mr. Joule, Mr. Lockyer, Mr. Perkin, Mr. Schunck, Colonel York, and others whom I could name, who are not in any way engaged in teaching, and never have been, but who have made important original researches, and have spent a good deal of their time in the working out of new discoveries. Now that method of stimulating research, which I have mentioned in my former examination, would not of course apply to them. Men of this class are really peculiar to England, for I have never known any such instance in Germany or in France, of men altogether disconnected with teaching taking up research in the way it is done in England. I think that for such men the establishment of national institutions such as those which are recommended by Colonel Strange would be peculiarly useful. In fact, I have heard several of these gentlemen express strong opinions as to the great advantage it would be to them if they could go to some institution of that kind to conduct research, where expensive instruments, which are often required for their experiments, were provided for a number of such investigators, and where appropriate rooms for carrying on those researches could be had. It is exceedingly difficult to carry on chemical research in one's own house, because of the want of proper contrivances for dealing with corrosive gases and vapours; and hence appropriate buildings ought to be provided for carrying on such investigations. I think, therefore, that it would afford a great stimulus to research of this kind if such institutions were provided, and furnished with such instruments as would be generally useful in research, leaving the more special instruments and apparatus adapted to the particular researches themselves, to be provided by each operator. By such a provision of buildings and apparatus, I cannot doubt that many more of our educated countrymen would engage in scientific research. They would not be so entirely thrown, as they are at present, upon field sports and literary pursuits. For their amusement, and for the cultivation of their minds, there would be the great resources of science open to them. And I have reason to believe that no inconsiderable number of men, more especially of those educated in some of the science schools, would undertake researches if such facilities were afforded them.

11,065. Would you consider the chief use of such institutions as laboratories to be to enable private inquirers to carry on their researches, or would you propose that any investigations should be carried on there on behalf of the State?—I think that both things might be provided for. The State requires many important investigations to be carried on. Such investigations are being continually conducted in buildings often very ill-adapted for the purpose, and which are fitted up for the purpose at a great cost. The laboratory of the Rivers' Commission, for instance, which we have occupied for four years, was constructed in a house in Victoria Street; a rent of 200*l.* a year is paid for it, and it is literally nothing more than a moderate sized room, and two smaller ones, very ill-adapted for the purpose. Consequently this laboratory is not so efficient as a building erected for the express purpose of conducting such investigations would be. That might well form one part of the objects of such a building, but I should think that so far as abstract research, of which we are more especially speaking, now is concerned, the other portion of those objects, namely, the encouragement of original investigation in the case of amateurs would be more important, because the investigations made for the Government are essentially practical investigations; they are not usually of that character which lead to discoveries or to the advancement of science.

11,066. Would you place those laboratories under a permanent official?—They must of necessity be under the direct and constant superintendence of some one thoroughly conversant with the operations going on in them; and, so far as the conducting of the separate original researches is concerned, I think that it would be very desirable that the admission into such institutions should be granted through some such body as the Research Fund Committee, for instance, of the council of the Royal Society, or some body of that kind, who would make intelligent and impartial inquiry into the qualifications of the men applying for accommodation.

11,067. You would not throw upon the director the sole responsibility of deciding who should be admitted and who should not?—I think that would not be desirable.

11,068. And I understood you to say that you would not think it desirable that the Government should direct any specific original research to be carried on, except with reference to some practical purpose?—Except with regard to subjects about which the Government wished for information, I think it is much better for each man to devise his own research; he takes much more interest in it, and is much more likely to pursue it with vigour than if it is prescribed for him.

11,069. And do you think it would be requisite that those institutions should be on a large scale?—I think that they ought to be upon a fairly large scale even to begin with, because it is always a costly process to rebuild such institutions; and I am inclined to think that they would be rapidly filled. A tolerably large institution of that kind would probably in a very few years be filled with workers.

11,070. You would not recommend, in the first instance, at least, more than the establishment of one for each department of science?—I think not more than that.

11,071. And should it be in London?—Yes, I suppose they must be commenced here, but eventually it would be desirable that the important centres in the provinces should also be furnished with such places.

11,072. Colonel Strange recommended the establishment of four laboratories; should you be disposed to agree with him in that view?—Yes, I think that those would be necessary; perhaps the least essential of them would be the metallurgical one, but certainly the others would be quite essential.

11,073. Could that be combined with the chemical

E. Frankland, Esq., Ph.D., F.R.S.

8 May 1872.

laboratory?—I think the metallurgical one, in the first instance, might be combined with the chemical laboratory, as the processes are similar. There would be the chemical laboratory, the physical laboratory, the physico-astronomical, as we may term it, and the biological. It would be necessary, in connexion with the physico-astronomical observatory, to have the means of performing various chemical experiments and making physical observations. Of course the chemical operations would be quite subsidiary to the cosmical observations there.

11,074. Are you prepared to express any opinion as to the way in which scientific aid is sought in parliamentary committees and in courts of justice?—Yes, I have had for many years past considerable experience in the way in which scientific aid is sought and given in both these cases, and it has always occurred to me that nothing could be worse than the way in which such things are now conducted. I believe that the giving of evidence in parliamentary committees and in courts of justice by scientific men has done a great deal to bring science into discredit, not to say into contempt in this country. There is no counterpart of the method employed here in Germany, where the experts employed in such cases are always placed upon neutral ground, and they make their investigations without any bias in favour of one party or the other. They are called in either by the Government or by the court, whereas here they must be called in by one party to the suit or to the bill, as the case may be.

11,075. In speaking of parliamentary committees, you refer to evidence given before private bill committees chiefly?—Yes, chiefly, but that is also to some extent the case with public committees, because there are generally interested parties, and they engage their scientific witnesses, whom they induce the committee to call, so that the same evil is found there, although it does not occur to quite the same extent. If the inquiry is somewhat of an abstract nature, and does not involve great commercial interests, I believe that there is very little of this objectionable mode of getting evidence going on in the case of public committees. But when large commercial interests are at stake, I am afraid there is much the same objection to the way in which scientific evidence is sought and obtained in public committees as there is in the private ones. It is impossible for a scientific man, called in as he is at the present time in those cases, to arrive at a sound and impartial judgment on the subject before him, because the party who seeks his help carefully conceals from him, or is perhaps ignorant of, many things that would prejudice his side of the case.

11,076. (*Dr. Sharpey.*) Are you aware that it has happened that scientific men have made a point of declining to give evidence in cases of the kind which you refer to, in consequence of the prevalence of this objectionable system?—That has not unfrequently been the case. I know one or two prominent instances of that kind, where they have declined altogether. And it is not uncommon for other scientific men who do not decline altogether to decline in a certain number of cases in which it is evident that their aid is sought not for the purpose of arriving at the truth, but with the object of advocating a client's case.

11,077. (*Chairman.*) In Germany are the parties to a suit prohibited from calling professional evidence in support of their side of the question?—I am not aware whether there is any distinct legal prohibition, but I have understood, on making inquiries in Germany from my scientific friends there who are in the habit of giving this evidence, that, as a matter of fact, the experts called in are always upon neutral ground.

11,078. Possibly that is owing to the public opinion of the country being adverse to such a system as exists in this country?—Possibly it is.

11,079. Can you suggest how it would be possible to introduce such a system in England, so as to secure the neutrality of any evidence of that character?—The employment of scientific witnesses by the Government or by the court in which the action is being tried, would completely get rid of this objection. But probably a better plan would be to call in the aid of such a council as that which Colonel Strange has proposed,—a council of scientific men, or a sub-committee of that council. I think that the functions of that council might very well be extended to the giving of advice of this kind to the Government and to the bench.

11,080. Would you think that the court should be prohibited from receiving any evidence except from scientific persons so recommended?—I think that would be too strong a measure. I do not think it would be possible or desirable to do that; but the evidence of a witness called by either side would naturally have far less weight than the evidence of a council called in without prejudice to either side.

11,081. Do you think it advisable that the judges should be empowered to call for such evidence even if the counsel on neither side asked for it?—Yes, I should think that very desirable.

11,082. Are you acquainted with Colonel Strange's proposal for the establishment of a consultative council of science?—Yes, I have heard from him some of the chief ideas that he entertains on that subject.

11,083. Are you disposed to consider that such a council would be desirable?—I think so. I am not prepared to say that it should be constituted exactly in the way that Colonel Strange mentioned, but a council of that description would be exceedingly desirable on many grounds, for furnishing the Government with trustworthy scientific opinions in cases requiring them, and also in supplying courts of justice with such opinions when required.

11,084. Have you formed any opinion as to whether it should be a numerous body, or somewhat select?—It would be better not to be too numerous. It struck me that the number proposed by Colonel Strange was rather excessive. A considerably smaller number than that would make a better working council probably than the more numerous one. If it were absolutely necessary to have so many upon it, it certainly ought, I think, to be subdivided into committees, or separate councils.

11,085. You would not consider it indispensable that every branch of science should have a representative on the council?—Not every branch, but all the most important branches ought to be represented. The chief branches of science are becoming more and more separate every day, so that a biologist, for example, would not be able to give a trustworthy opinion upon a chemical question, and *vice versâ*. Every important branch, therefore, ought to be represented, but that need not involve probably more than half-a-dozen members of the council.

11,086. Are you of opinion that the advice of such a council, even on matters to which the larger proportion of the members of the council had not paid special attention, would be valuable?—Yes, I think it would, because those members of the council who were thoroughly acquainted with the subjects would be expressing their opinion to men conversant with scientific methods, and they would be able to convince their colleagues with respect to the opinion that the council generally ought to give upon the matter. It would be a very different thing from that of convincing a parliamentary committee, for instance, upon a scientific point, because all the men upon the council would have received a scientific training, and would understand the bearing of scientific arguments.

11,087. Have you considered at all how such a council could best be appointed, whether would you leave it to one of the ministers to appoint and select the proper persons to serve on the council?—I should think that it must ultimately fall upon the minister, but he might be assisted, by the presidents of different learned societies, or by the council of the Royal Society, in whom I think everyone would have confidence.

11,088. You would probably contemplate that the members of the council should be paid?—Yes, I think that would be absolutely necessary, because I would also make it a *sine quâ non*, that the members of this

E. Frankland, Esq., Ph.D., F.R.S.

8 May 1872.

council should not hold any patents or be engaged in any commercial enterprise.

11,089. (*Dr. Sharpey.*) You would contemplate laboratories specially devoted to research not combined with teaching laboratories for the higher departments of science?—Yes, in what I said just now I referred to laboratories disconnected from teaching altogether.

11,090. Even the higher scientific instruction?—Yes.

11,091. Do you think that that would apply all over the country. In such a place, say, as Manchester, where there may be a laboratory for the higher scientific instruction, chemical instruction for example, might it not be convenient and economical to so arrange it that it could be used for research?—I think so. The establishment of such research laboratories in the provinces might, in the first instance, be carried out with advantage in connexion with existing institutions in which the higher branches of science are taught.

11,092. With regard to the large number of original memoirs presented to the German Societies, where are the researches carried on from which those memoirs are derived?—They are all, without exception, carried on in laboratories connected with teaching institutions in Germany.

11,093. If it answers in Germany, would it not answer here?—Yes. As I have said before, I believe that that is the main thing to be done in this country in the way of advancing scientific research,—the making it a necessity for the teachers themselves to conduct research and devise researches for their students. That I believe is the secret of the activity in Germany. There, each professor is selected for his professorship, almost invariably, from his having made researches of importance in his particular branch of science, and he is called upon continually to devise researches for his pupils, who require to make those researches in order to be admitted to examination. Students are not admitted to examination for their degree unless they can present a memoir upon the research which they have conducted. Many of those students, most of them I suppose, would be incapable of devising the original idea of research, but having an idea given them they carry it out; and, having thus become familiar with the methods of research, a large number of them go on making discoveries afterwards.

11,094. You would approve of that mode of carrying on research being adopted and encouraged in this country?—Yes, very strongly.

11,095. But still you would recommend independent laboratories of research, if I understand you rightly? Yes, for the use of those gentlemen (who are, as I have said, rather numerous in this country) not connected with teaching at all. Separate institutions established in the first instance would be calculated to promote research to a considerable extent, but to nothing like the extent to which the other recommendation I have made would lead.

11,096. Do you think that that would be more advantageous than giving opportunities to those gentlemen to carry on their original researches in those educational establishments to which you have referred?—If the educational establishments were provided with sufficient space, and with the necessary apparatus, I do not see any objection to combining the two things together.

11,097. It is so at Bonn, for example, is it not?—Yes, it is so at Bonn, and Berlin, and Zurich, and various other places on the continent; but in these laboratories, students and professors only work at research. The class of amateur investigators, for whom I have suggested special provision, does not exist, to the best of my knowledge, in Germany, France, or Switzerland.

11,098. Are arrangements made for beginners, and arrangements made for students, who have made considerable progress, and for young chemists engaged in research?—That is so, they have separate laboratories for each class of workers.

11,099. And do you think that that is an advantageous arrangement?—Yes, I think that that would quite meet the point, provided a sufficient outfit of the more expensive apparatus were provided for the persons engaged in research.

11,100. (*Chairman.*) Do you know how the inquiries which the Government may consider necessary are provided for in Germany, how are they carried on?—They usually appoint a commission of two or three scientific men.

11,101. Then the Government laboratories are institutions which they can make use of for the purpose?—Yes, the large Government laboratories.

11,102. But there are also teaching institutions connected with the Universities not solely for the use of the Government?—Yes, but still the Government feels itself entitled to make use of those laboratories, and all Government inquiries are conducted in such laboratories.

11,103. Do you mean such inquiries as you have referred to connected with the Rivers' Commission?—Yes. I may mention that in some of the new chemical laboratories, there is a special department for conducting inquiries connected with Medical Jurisprudence,—testing for poisons in cases of poisoning, and similar operations.

11,104. Then if the Government rendered any assistance more directly to provincial institutions in the way of grants, do you think that they might stipulate as a condition that they should be allowed to make use of them for their own purposes if necessary?—Yes, I think that that would be perfectly fair.

11,105. (*Dr. Sharpey.*) Are you quite satisfied that were a laboratory exclusively intended for research of the kind you first referred to, established in London, it would always find sufficient employment, and that there would be no risk of its being, so to speak, idle?—It would necessarily be of the character of an experiment in the first instance. This is a thing which exists nowhere. We know what teaching will do, because we have plenty of examples of it in other countries; but this thing exists nowhere; and it seems to me that it would only have a chance of existing in this country. There are no people of that kind in France or Germany, at all events as far as I know.

11,106. Do not you think that the safer plan would be rather to extend the laboratories connected with teaching institutions, and afford opportunities for amateurs to work there, than to establish a separate institution altogether, to supply the probable wants of those gentlemen?—I think that research in connexion with teaching is by far the most important, and ought to precede the establishment of separate laboratories for amateurs.

11,107. (*Professor Smith.*) You might place also a laboratory for research at a little distance from London, where you would have the facilities of ground and cheapness of building, whereas you could not place a laboratory for instruction anywhere excepting in the metropolis if it were to be a metropolitan institution at all?—Yes, there would be a greater facility for having such institutions some little distance out of town. So many people would not have to go to them every day, as is the case with teaching establishments.

11,108. (*Chairman.*) Are there any other matters connected with the evidence which you have been giving upon which you would like to make additions?—There is nothing more that I wish to say.

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 10th May 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

General SIR EDWARD SABINE, R. A., K.C.B., F.R.S., examined.

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

11,109. (*Chairman.*) You were so good about two years ago, in reply to a letter addressed to you by the Secretary of our Commission, to furnish a statement with regard to the administration of the annual grant of 1,000*l.* placed by Parliament at the disposal of the President and Council of the Royal Society. With regard to this grant, do you consider that it has been of great service in the advancement of science?—I think it has been decidedly of considerable service.

11,110. Do you consider the sum to be sufficient?—That involves a good many questions; the sum is what the Government spontaneously allotted in the first instance.

11,111. Do you think that if the sum had been considerably increased much more might have been done towards the advancement of science?—I suppose that much more good might have been done towards the advancement of science if the sum had been considerably increased (always presuming its judicious administration); because even under the present circumstances much good has been done, and if the grant had been larger there would probably have been as much or even more care taken in the expenditure of the money by the persons to whom it was entrusted; and the resulting advantage would in such case have been more considerable.

11,112. You think they would have had no difficulty in the administration and distribution of a much larger sum?—I think some changes would have been necessary for that purpose. We must then have had, besides the Government Grant Committee, a person officially appointed for the general superintendence of the allotments and expenditure; and he must have been recompensed in some way. I think it is very desirable that the person who superintends the allotments should be in communication with the persons who are the recipients; and should hear from them from time to time what progress they are making; and should eventually draw up a notice with regard to each grant, when the money had been expended, as to what had been done, and as to any desirable continuance or extension. But such amount of superintendence would require more money, for it would not be right to put such duty on any individual without salary. But a salary could scarcely come out of the Government grant at its present amount; and it could not with propriety be taken from the contributions of the Fellows of the Royal Society. The case would require to be met by some special provision.

11,113. The improvements which you think desirable could not be introduced under existing circumstances then?—I think they *could* be introduced.

11,114. But not without some change, I suppose?—Certainly. I addressed a letter to that effect to the Treasurer of the Royal Society two years ago, in which I suggested that a change might be attended with considerable advantage. But it may be difficult to see how the matter could be managed, principally on account of the necessity there would be of allotting a salary to some individual, as you could not expect the work to be done without some pecuniary recompence. The Government grant of 1,000*l.* would scarcely bear the deduction of a scientific salary; and it would not be fair to charge it on the contributors to the Royal Society.

11,115. Have you considered at all what salary would be sufficient?—No; because I thought it probable that before long there would be some change with regard to the amount of the grant, or the distribution, of the working; and that that would be the proper time for taking a new view of the mode of its superintendence.

11,116. Unless the amount of the grant was considerably increased the salary could not reasonably be made a large one?—If the grant be considered to have done good under its present circumstances, possibly it might be considered desirable to augment it; and, in such case, its management, if I may so call it, or rather the watching over it, might be a very proper subject of fresh expenditure, and would probably contribute greatly to its being applied to good uses.

11,117. I believe that in the year 1857 the question of the working of the grant was submitted to the Government Grant Committee by the Royal Society; and the Committee, on that occasion, were requested to consider, and report to the Society, whether any measure could be adopted by the Government which could improve the position of science or its cultivators in this country; do you remember that report?—I took great interest in the subject, and remember it very well.

11,118. The distribution of the money was one of the points raised on that report, was it not?—That, I think, was regarded as a very important matter. There was a good deal of consultation at the time; Lord Wrottesley, then P.R.S., was anxious that there should be something like the old Board of Longitude reconstituted, and that brought us into the very matters that this Commission has had under its consideration lately.

11,119. (*Sir J. P. Kay-Shuttleworth.*) Will you kindly read that document in order that it may form part of your evidence?—Yes, the report was as follows:—

"With regard to the question of which the consideration was referred to the Government Grant Committee on the 11th of July 1855, namely, whether any measures could be adopted by the Government or Parliament that would improve the position of science or its cultivators in this country, the Committee beg leave to recommend the following resolutions:—

"1. The Committee regard with much satisfaction the steps already taken in the Universities for advancing the study of physical science by including several branches of it in the public examinations, and express their hope that the improvements thus introduced may receive the extension which the interests of science require, and that the public schools may be thereby induced to make physical science an integral part of their course of education.

"2. The Committee recommend that the establishment of classes in metropolitan and provincial schools, where those who have not the means or opportunity of studying at the Universities may be taught the elements of physical science on a systematic plan, be promoted by grants from Government in aid of such funds as may be locally contributed for that purpose.

"3. That the formation of provincial museums and libraries be encouraged in like manner, and that provincial lectures, accompanied by examinations, be established in Great Britain in towns which request this assistance, and engage to provide a part of the expense, such lectures to be in aid of the schools above-mentioned, so that by means of the two combined a sound knowledge of the principles and application of science may be systematically taught.

"4. That duplicate specimens from the British

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

Museum and other institutions, supported at the public expense, be distributed to provincial museums.

"5. That national publications bearing on science be more extensively circulated than they are at present by additional donations to societies and individuals engaged in the cultivation of science.

"6. That the sum placed annually by Parliament at the disposal of Government for the reward of Civil Services, 'useful discoveries in science and attainments in literature and the arts,' be augmented; that the portion to be appropriated to science be defined, and that it be sufficiently large to admit of the grant of annuities of the nature of good service pensions as rewards of eminent scientific merit.

"7. That the sum placed at the disposal of the Royal Society for the advancement of science be not necessarily limited to the annual grant of 1,000*l.*, when on any occasion special reasons may be assigned for an additional sum.

"8. That scientific officers be placed more nearly on a level in respect to salary with such other civil appointments as are objects of ambition to educated men.

"9. The Committee regard with much satisfaction the steps already taken for the concentration of the principal scientific societies in Burlington House, and trust that the period is not far distant in which permanent accommodation will be afforded to the principal scientific societies in buildings to be erected near the same site, and in pursuance of the same general plan.

"10. While it may not be expedient to interfere in any way with the functions confided to the President and Council of the Royal Society in reference to the distribution of the Parliamentary grant, or with the ancient and recognised relations between the Royal Society and the Government, at the same time it appears to the Committee that much benefit would arise from the formal recognition of some board which might advise the Government on all matters connected with science, and especially on the prosecution, reduction, and publication of scientific researches and the amount of Parliamentary or other grants in aid thereof; also on the general principles to be adopted in reference to public scientific appointments; and on the measures necessary for the more general diffusion of a knowledge of physical science among the nation at large; and which might be consulted by the Government on the grants of pensions to the cultivators of science.

"11. Assuming that the above proposal should meet with the approval of Her Majesty's Government, it will be desirable to ascertain what mode of constituting such a board would inspire them with most confidence in its recommendations. Two modes may be suggested in which such a board might be organised. First, the Government might formally recognise the President and Council of the Royal Society as its official adviser, imposing the whole responsibility on that body, and leaving it to them to seek advice when necessary in such quarters as it may best be found, according to the method now pursued in the disposal of the parliamentary grant of 1,000*l.* The second method would be to create an entirely new board, somewhat after the model of the old Board of Longitude, but with improvements. The question as to which alternative shall be adopted is properly a subject for the consideration of the Government.

"12. Such of the above recommendations as involve the expenditure of money, might be eventually carried out by appropriating to this purpose a certain portion of the fees received from the grantees of patents, after providing for all expenses which ought to be defrayed from that source. The Committee are satisfied that no application of these fees could be devised more appropriate than the devotion of a portion of them to the encouragement of abstract science, to which practical art is under so many and such important obligations."

11,120. (*Chairman.*) In that report occurs this recommendation:—"Two modes may be suggested in "which such a board might be organized; first, the "Government might formally recognise the President "and Council of the Royal Society as its official "adviser, imposing the whole responsibility on that "body, and leaving it to them to seek advice, when "necessary, in such quarters as it may best be found "in, according to the method now pursued in the "disposal of the parliamentary grant of 1,000*l.* The "second method would be to create an entirely new "board, somewhat after the model of the old Board "of Longitude, but with improvements. The ques- "tion as to which alternative shall be adopted is "properly a subject for the consideration of the "Government." Have you any opinion yourself on that subject, with regard to which would be the best mode?—I was present at a very interesting discussion between Lord Wrottesley and the present Lord Derby (then Lord Stanley) on the subject. The conclusion I drew, mainly, I think, from the observations of Lord Stanley, was in favour of its continuing in the Royal Society, rather than in a reconstitution of the old Board of Longitude. The opinions were very strong on both sides, and I rather inclined in the result to think that Lord Stanley took the most practical view. Your Grace is aware that the Council of the Royal Society has the power of calling to its aid at any particular meeting, for any special purpose, any Fellows of the Society, or, I believe, indeed, persons who are not Fellows of the Society, but possessing special knowledge, who then act in all respects at that particular council as members of the council.

11,121. If the President and Council of the Royal Society were recognised as the formal official advisers of the Government, it could scarcely be expected that any great increase in the duties to be involved in such a position could be undertaken without some remuneration?—I think that in respect to the superintendence of the allotments of the Government grant, it is a special matter in which some compensation might reasonably be made; but apart from that, I do not think it desirable that the members of the Council of the Royal Society should receive any remuneration.

11,122. If a large portion of their time were taken up, would you not think it desirable that they should be remunerated?—In particular cases, a special committee might be appointed, with such emoluments as it might be proper to recommend. Such was the case when Professor Faraday undertook his experiments on glass. I think the persons who were engaged in that committee were paid for their services.

11,123. Have you any recollection of the constitution of the old Board of Longitude?—Yes, I recollect it perfectly.

11,124. The duties of the Board of Longitude were not limited, as might be inferred from its title, were they?—Certainly not.

11,125. They comprehended all subjects connected with science?—Generally so; but especially matters connected with navigation.

11,126. It was presided over by the First Lord of the Admiralty?—Yes.

11,127. And there were also one or two members of the Board of Admiralty on it, were there not?—Yes, Sir George Cockburn was almost always present, as were the secretaries of the Admiralty, Mr. Croker and Mr. Barrow.

11,128. Do you recollect the circumstances that led to the abolition of the Board of Longitude?—The Astronomical Society had been recently established at that time, and there was a great deal of private opposition between Mr. Francis Baily, who took much personal interest in the Astronomical Society, and Dr. Young, who was secretary of the Board of Longitude. Dr. Young wished to retire from the Board, and if he had done so, I believe it was generally felt that in him the board would have lost one of its most useful members. Mr. Davies Gilbert, who had much influence at the time in such matters, seeing no way of restoring harmony, was understood to have suggested the abolition of the board.

11,129. Is it your impression that the Board of

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

Longitude rendered valuable services to the country during the period of its existence?—Yes, matters were frequently referred to them of which they were an admirable board for judging; that was often so to my knowledge.

11,130. The cost of that board was very trifling to the State, was it not?—Yes.

11,131. Most of the members were *ex officio*, I believe?—Yes, most of them were *ex officio*.

11,132. The few members that were paid were paid but a very small salary, I believe?—I think the President of the Royal Society was an *ex-officio* member. Dr. Young was paid a salary. Dr. Wollaston and Captain Kater were members, but they were not paid.

11,133. Had this Board been many years in existence?—It had been many years in existence. I do not immediately remember the date of its origin, but it was before my time; it took its origin in times when rewards were given for the discovery of means for determining the longitude.

11,134. I see among the recommendations contained in the Report from the Government Grant Committee there is the following:—"That the sum placed "annually by Parliament at the disposal of Govern- "ment for the reward of civil services, useful disco- "veries in science, and attainments in literature and "the arts, be augmented; that the portion to be "appropriated to science be defined; and that it be "sufficiently large to admit of the grant of annuities, "of the nature of good service pensions, as rewards "of eminent scientific merit." Do you agree in that recommendation?—Yes; I did agree in that recommendation.

11,135 Lord Russell, at the time that committee was appointed, gave them full permission to give annuities out of the 1,000*l*., did he not?—Yes, permission was given to grant annuities. I suppose that the 1,000*l*. in one year was designed as an experiment to try the matter in the first instance. I always understood that Lord Russell contemplated that the sum would be augmented if the plan were found to work well.

11,136. In this report it rather appears as if two different sums were contemplated, namely 1,000*l*. to be applied in the same way as it had hitherto been applied, and a further sum for other objects?—I believe that it was Lord Russell's intention that the sum should be augmented after a time; it was an experiment at first, both with regard to the country, and to the Society. At first there was great difficulty with the Royal Society in accepting the trust. It was understood that Lord Rosse was not favourable to the proposition of a grant, for the application of which the Royal Society should be responsible; other members of the Council were in its favour.

11,137. Is there any class of scientific questions that are not brought before this Government Grant Committee from the consciousness that it would involve too large a sum of money to be entertained?—The committee can grant temporary assistance towards objects which they approve, and thus proceed by degrees, and they have done so. I may cite the example of Mr. De La Rue's researches regarding the sun spots. He began with a small sum, and it has been continued, and it is probable that the result will show that a much larger sum will be required.

11,138. (*Professor Huxley.*) I think Mr. Lockyer once applied for a grant for a large telescope, and the application was not considered, because the amount which would be required for the purchase of such a telescope would be too large; was not that so?—I have not a perfect recollection of the fact. In the first application, I believe, he did not ask for a sufficiently large sum. But a second application was made, when it may have been said that if he had applied for the whole amount at first it would have been better. After the telescope had been made it was not supposed to prove so useful as it might have been, because a sufficient sum had not been applied for in the first instance. I think Mr. Lockyer applied for an additional grant, and I hope he obtained it. In cases where the money required has been beyond the means at the disposal of the Government Grant Committee, the Royal Society has aided, I believe. In the case of the telescope of Mr. Huggins, 2,250*l*. was, I think, the amount granted.

11,139. (*Chairman.*) Have there been frequently cases in which, on the recommendation of the Royal Society, the Government has given special grants for special objects?—Certainly. The Government, I apprehend, look to the Royal Society to make such recommendations, when the Society considers the occasion sufficiently important. It is, indeed, quite a part of their duty to the State to do so.

11,140. Are such applications of frequent occurrence? In the course of the year are there usually one or two recommendations of that kind?—Scarcely so many as that; but I think it is because cases are not brought before the Royal Society. The Society would never desire to stop them; and if there were more than one in the year they would not stop them on that account; they might, perhaps, hesitate to recommend (in cases of large amount) on account of the particular circumstances in which the country might be placed at the time.

11,141. Is it generally known among scientific people in the country that there is that kind of relation between the Government, and the Royal Society?—I know no reason why it should not be generally so understood.

11,142. I believe at present that personal expenses are not included in the Government grant?—They are not; but there is a liberal construction as to what are personal expenses; properly speaking personal expenses, as such, do not make a part of the grant, but I am far from saying that some personal expenses may never have been covered by the grants. No specific account is brought before the Society of the expenses incurred.

11,143. Is it intended that there should be any remuneration for the time employed in making special researches?—Certainly not.

11,144. There is no restriction in the terms on which the advance is given by the Government?—No; nor is there any detailed account required from the individual.

11,145. It is placed at his disposal, is it not?—It is.

11,146. (*Professor Huxley.*) Witnesses who have come before the Commission have spoken of the desirability of establishing a physical laboratory at the expense of the State, at which instructions in physical science, which are beyond the reach of private persons, could be carried out. Supposing an application of that kind to come before the Government Grant Committee which would involve an expenditure of say from 10,000*l*. to 15,000*l*., would that application be entertained at all by the committee, or what would be done?—They would probably recommend that it should be brought before the President and Council of the Royal Society, who would call to their assistance any persons in the country whose position or circumstances, or special knowledge might aid them, and who, for that particular occasion, would be regarded as members of the Council.

11,147. But such persons would have no vote, I suppose?—I believe that such persons would have votes in the meeting of the Council at which their presence had been requested.

11,148. May I also ask if you consider that the constitution of the Government Grant Committee is such as to make it a convenient and proper body for administering a much larger sum than that which is now at its disposal, or would you, supposing the sum to become very much larger, suggest any modification of its constitution?—I should suppose, that if the sum were (say) to double the amount, no modification might be required; but, if you increased the annual grant to 10,000*l*. or 20,000*l*. in a year, it would probably be deemed desirable to meet the case by some new or special arrangement.

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

11,149. What I wished to ask you was rather this, whether, supposing the sum at the disposal of the Government Grant Committee were increased ten or twentyfold, you would be prepared to suggest any modification in the constitution of the committee?—Yes.

11,150. Of what nature?—I am scarcely prepared to reply fully to that question on the instant; but if it were put more simply, thus, Should the funds allotted annually to the Government Grant Committee be increased to the extent of 10,000*l*., 15,000*l*., or 20,000*l*., in that case, should there be special directions or improvements as to the administration? I should answer, Certainly, there would require to be some. I should think it very desirable that there should then be a revision of the whole subject.

11,151. I believe I am right in stating that at the present moment the Government Grant Committee is practically nominated by the Royal Society?—Yes.

11,152. Persons outside the Royal Society have no power of electing the members of the Government Grant Committee, have they?—No, the members are named by the council.

11,153. So that, in fact, the body is really created by the Council of the Royal Society?—Yes, it is a Committee of the Royal Society.

11,154. (*Dr. Sharpey.*) I should like to ask your opinion whether, in the case of the functions of the Government Grant Committee coming to be much more important than they are now with reference to the sum under its administration, you would consider it advisable that the Government itself should be consulted with regard to the nomination of the committee, or of a committee?—That is rather a question for the Government to decide. They give the money, and it would rest with them to decide who should form the proper committee to allot it; they might, perhaps, prefer leaving it to the Royal Society, and, on the whole, that might be the safest plan.

11,155. In case of any payment in the shape of salary being made to the secretary of the committee, or to any of its members, do you not think that in that case the Government would require to have some voice in the selection of them?—No; I do not think they would ask it, and I do not think it would be desirable on any account. In reference to the subject generally, I may mention that Lord Rosse asked me to superintend the administration of the Government grant at its commencement; I did so for the first five years, and in my former evidence I have stated, in the majority of cases, the conclusions which my correspondence with the recipients enabled me to draw.

11,156. (*Chairman.*) Why was that practice discontinued?—My other duties obliged me to discontinue the superintendence after the first five years.

11,157. Did it take up a great deal of your time?—It did; but not without some personal recompense, in being thus placed in communication with persons who were engaged in the various researches.

11,158. Does the Royal Society annually make any report to the Government on the distribution of the grant?—Yes.

11,159. But without any explanation of the results?—Yes.

11,160. (*Dr. Sharpey.*) Does it occur to you that a scientific inquirer desirous of undertaking a research in a particular direction, might, perhaps, be deterred from making an application if he thought he was bound to state a positive result which could be reported?—Under present arrangements he is left quite free. Should his experiment or researches fail altogether in producing the expected result, the responsibility rests with those who sanctioned the expenditure, not with the person who proposed it.

11,161. (*Sir J. Lubbock.*) A negative result might, in some cases, be as instructive as a positive result?—Possibly so; there have been more than one case in which the committee have given grants of money, notwithstanding the impression in the mind of many of the members that the result would disappoint the applicant.

11,162. (*Chairman.*) Are applications frequently made to the Government Grant Committee in larger numbers than it is possible for them to meet, on account of the insufficiency of the fund?—I believe not. I do not think that has been hitherto complained of. People feel, I think, that if the amount they ask for would run the amount at disposal very close, they had better reserve themselves for another time.

11,163. If the grant were increased tenfold, do you think that the applications would come in in greater numbers?—I think probably a great many applications that had better not be attended to would come in.

11,164. Do you think that 10,000*l*. a year would be more than the society could satisfactorily dispose of?—It would be difficult to answer that question without knowing how largely the demands of science may be expected to increase. If there were an increased prospect of getting money, there is a vast deal to be done in science; and an increased number of applications might be expected.

11,165. (*Sir J. Lubbock.*) I think there are every year many grants which the British Association would be glad to make, but which it is compelled to decline on account of the limit to its funds. Are you aware of that?—I have not attended lately the meetings of the British Association, and I am hardly able to answer that question.

11,166. Assuming that to be so, those applications might naturally be made to the Royal Society, might they not?—I think the applications to the Government Grant Committee might be increased with great advantage to science, if the amount disposable were increased also.

11,167. (*Chairman.*) Would you recommend an immediate increase of this grant?—I am hardly able to answer that question. I think it should be for those who are carrying on inquiries in science to answer it; they would be more able to speak on the subject than I am. The particular branches of science which I have been engaged in latterly are now well provided for. They are going on well, and I do not think they want more money than they have; but there are a great many sciences where it might be an advantage.

11,168. (*Sir J. Lubbock.*) Do you not think that a certain amount of money might be spent with advantage in the work of publication?—Very possibly.

11,169. In biology, particularly, might not many works, with great advantage, be more richly illustrated than, owing to the want of funds, is now the case?—Probably; I have no special knowledge.

11,170. (*Dr. Sharpey.*) I wish to ask your opinion whether, in the case of an application being made to the Government, independently of the Royal Society, for aid for the advancement of science, you would consider that the Council of the Royal Society would be a proper body for the Government to refer to for advice?—The Royal Society would undoubtedly be a highly suitable body for such reference. That was one of the original purposes for which the Royal Society was constituted more than two centuries ago.

11,171. If aid were asked for the establishment of a physical laboratory, or for some object involving a considerable expenditure, would the Council of the Royal Society be a suitable body for the Government to apply to for advice?—It ought to be so.

11,172. (*Chairman.*) Is assistance towards the publication of scientific works considered to be one of the purposes to which the Government grant can be properly applied?—Grants for such purposes have been made in special cases. In fact the Government Grant Committee have very extensive powers, more than they have ever exercised; for instance, they have the power to grant annuities.

11,173. Should you like to see that power exercised? No, I would rather not see annuities so granted. But probably the Government wished to shield themselves from applications.

11,174. (*Dr. Sharpey.*) Do you remember that

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

grants have been made from time to time for the publication of Star Catalogues?—Yes.

11,175. And some publications that might be considered really as supplying materials for original inquiry, if we might use the expression, such as Mr. Etheridge's Catalogue of Fossils, for example?—The Markree Catalogue of Stars was published either in whole or in part by a grant from the Government Grant Committee. It is a case in point.

11,176. And also Dr. Robinson's Astronomical Observations?—That also.

11,177. (*Professor Huxley.*) Has not this difficulty arisen with regard to the administration of the Government grant on some occasion, that when officers employed by the Government have wished to publish a scientific research made by them in that capacity, the Government has thought that the Government Grant Committee was the proper source for the fund to come out of; while, on the other hand, the Government Grant Committee have been of opinion that they ought not to furnish funds to officers in the employ of the Government, and so the unlucky applicant has found himself rather between two stools?—I think that was nearly the case in an application in which you yourself were concerned. The Government no doubt in that case had virtually promised to make an expenditure, and you will remember the reply made by the then Secretary of the Admiralty was "that they had no money;" now, if they had no money, no money could be had; but the Government Grant Committee supplied the necessary amount, and I believe I was myself the person who proposed it.

11,178. Do you think that difficulty exists still; would it exist now?—I think not. I think there would be either more money, or more liberality in its expenditure. I thought yours a particularly hard case, because you had been employed by the Government, and there was a clear understanding that in the case of researches made by a person in the exercise of his public duties, the Government should assist in bringing the results before the public; but the reply was "that there was no money," and, of course, we could say nothing further.

11,179. (*Chairman.*) No part of the Government grant, I think, is applied in the shape of rewards for discoveries already made?—It might be so applied.

11,180. Do you consider that the extension of the grant for that purpose would be desirable?—I should say it would be a proper thing to represent to the Government that such or such discoveries had been usefully made, and that some consideration to the person who made them was due; but while the fund is limited as it is at present, the annual 1,000*l.* would scarcely admit of any part of it being so applied.

11,181. Did the Royal Society ever recommend anything of that kind to the Government?—It would be by no means unsuitable that they should make such recommendations; but I cannot remember of late years any instance of the kind.

11,182. Would they be unwilling to make such a recommendation unless their opinion was asked?—I think not if there were a clear case.

11,183. The Royal Society has for some time undertaken to prepare for publication a catalogue of scientific papers, and I believe that the expenses of the construction of that catalogue have been defrayed by the Royal Society, while the Government has undertaken to pay the expenses of the publication?—That is so.

11,184. Do you think it would have been reasonable to call on the Government to do more than they have done in that particular case, and to assist also in the expense of drawing up the catalogue?—I think it might have been reasonable to do so; but I think it has been a duty that has been performed willingly, and greatly to the credit of the individuals who have executed it, as well as reflecting credit on the Society itself.

11,185. I believe that a considerable sum of money has been expended by the Society on that object?—There has been 3,500*l.* expended. It is a small sum of money to have done so much good with.

11,186. This work is still in progress, is it not?—Yes, it is still in progress.

11,187. (*Dr. Sharpey.*) The particulars will be found in a Memorandum supplied by you for insertion in the Appendix, will they not?—I suppose so; the services that have been rendered by the Fellows of the Royal Society who have undertaken the execution of that work have been very great, and can hardly be estimated in money. It is difficult to estimate the money value of the labour of competent persons, who have devoted a very large portion of their thoughts and time for several years to the subject. It is a work which could not have been accomplished in any way other than by the assistance those gentlemen have given to it. [*See* APPENDIX XI.]

11,188. I think that in every case the title inserted in the catalogue has been copied from the memoir itself, and never at second-hand from any other list or catalogue?—It is so. It is one of those works which have been executed, it may be said, primarily by the Royal Society; but it *may* be also said, "concurrently by the Royal Society and the British Association," because it was first brought forward in the British Association, and afterwards taken up by the Royal Society; it has been executed under the care of the Royal Society, though the first project of the work was mooted at the British Association.

11,189. It was originally projected on a more limited scale altogether, was it not?—Yes, the present admirable execution of the work was not, perhaps, fully contemplated at the time when it was first proposed.

11,190. The British Association did not contribute in any way materially to the execution of it, did they?—No, but I think they would have done so if it had not been taken up by the Royal Society.

11,191. (*Chairman.*) Have heavy expenses been thrown on the resources of the Royal Society?—Much of the work has been voluntary.

11,192. Do you mean that the members have done it themselves?—Parts of the work have been otherwise executed, and paid for out of the funds of the Society.

11,193. Has it hampered them?—No. The Society are in better circumstances to undertake such works now than they used to be. Having been so deeply interested in such matters for many years, I may add that I very much hope that the society may continue to execute such public works; and I hope they may long have those as their officers who will aid in the execution as ably as has been done in this case.

11,194. They are able to provide, from their own funds, the means for executing such objects?—Much more than formerly. The publication now under notice will require continuance.

11,195. (*Sir J. Lubbock.*) Therefore, for some time to come, there will be a further demand on the funds of the Royal Society in that direction?—Yes.

11,196. Is it not, in your opinion, probable that the work will be continued?—The general appreciation of the work is so high that I entertain no doubt of its being continued; it is not only highly appreciated in this country, but by scientific men generally. You hear from all countries of persons engaged in science speaking so highly of its value, that I have no doubt it will be continued. We cannot expect that the gentlemen who have conducted it until now will continue to conduct it for many years longer, but there will no doubt always be found Fellows of the Royal Society who will be willing to contribute time and labour to a work of such value and importance.

11,197. That would involve a further expenditure of a considerable amount on the part of the Society, would it not?—Yes, surely; but I do not doubt that the Government would assist quite as much or even more than they have done if it were brought under their consideration.

11,198. (*Chairman.*) As a rule, do you find the Government willing to entertain favourably any recommendation from the Royal Society?—Remarkably

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

so; they have always been so, and are certainly not less so at the present time than they were formerly. I have had a good deal of experience, in the last 50 years, of the proceedings between the Government and the Royal Society in such matters, and the belief I have expressed is founded on that experience.

11,199. You cannot remember any important cases in which Government assistance has been refused when recommended by the Royal Society?—No.

11,200. The Royal Society was consulted by the Government with regard to the outlay incurred in the magnetic surveys at various times?—Yes.

11,201. Is any expenditure at present being incurred for that object?—Not so much as in years that are passed; but the progress that has been made in those surveys has led to the existence of a department in the Admiralty by which such inquiries are carried on from time to time, and the public hear nothing of them except in the result. Those surveys now go on as matters of routine, which was not the case formerly.

11,202. That is with regard to magnetic surveys solely, is it not?—It is the case in magnetic surveys. There is a department of the Hydrographic Office under a very competent person, Captain Evans, who now carries on all such inquiries in all parts of the globe; that department did not exist before the Royal Society first recommended to the Government the institution of magnetic observations in different parts of the globe.

11,203. (*Professor Huxley.*) I am right in saying, am I not, that the Royal Society itself derives no benefit whatever, either directly or indirectly, from the sums of money which are granted on behalf of the Meteorological Committee, nor from the grants made on behalf of the Government Grant?—None whatever.

11,204. You know, do you not, that, in the estimate presented to Parliament, the total amount granted in that way every year appears under the head of "Grants to Scientific Societies," and that a number of members of the House of Commons, I believe, are of opinion that that is money granted actually to the scientific societies for their own purposes?—I have heard of individual members of Parliament having been under some such mistake.

11,205. I may assume that within your experience of the Royal Society, the Government never has granted a single shilling, directly or indirectly, for the purposes of that society?—No, surely not, for its own expenses.

11,206. Not a shilling?—No. I cannot say whether the Society would or would not receive a grant if it were offered, but no such thing has ever been thought of, I believe.

11,207. (*Dr. Sharpey.*) There is a fact which you are probably cognizant of, namely, that, in Sir Joseph Banks's time, the Royal Society voted 500*l.* for the use of the nation at the epoch of the great French war?—Yes, that was an anomaly which belonged to the time at which it happened; it has never been adduced as an instance that should be followed.

11,208 Do you suppose that that sum was ever paid?—I cannot tell; there was a very natural and general excitement prevailing at that period, and we should not hold people very strictly responsible for their proceedings at such a time.

11,209. (*Chairman.*) A scheme was proposed with regard to pendulum experiments in India some years ago. Was the Royal Society consulted on that subject?—It was; and the experiments are now going on, and will be completed, I hope, next year. They have been admirably conducted in India; and the party will return to England next summer, when the experaments will be finally completed.

11,210. Are you satisfied with what is being done by the Magnetic Department under the Board of Admiralty now?—Very much so.

11,211. You do not think it necessary that it should be extended?—On that question Admiral Richards would, perhaps, give the Commission the best advice, but I think everything appears to be admirably conducted in every way.

11,212. The Royal Society was also consulted with regard to the formation of the Meteorological Department of the Board of Trade, and they furnished the Government with a very full statement of their views with regard to what it was desirable to aim at in establishing such a department, did they not?—Yes.

11,213. I believe that, from various causes, the original intention was not strictly carried out?—It was not fully carried out at that time, viz., in 1853.

11,214. And at the time of the death of Admiral FitzRoy the Royal Society were again consulted, were they not, with reference to whether it would be advisable to make any changes?—Yes.

11,215. The Royal Society, on that occasion, made some recommendations to the Government, I believe?—Yes.

11,216. Is the Meteorological Department at present, in your opinion, in a satisfactory state?—In my opinion it is so; but I must add that I am the Chairman of its superintending committee.

11,217. That is a Department of the Government which is under your control to some degree?—I suppose it may be so said.

11,218. Do you do more than give advice?—Yes, I attend the weekly meetings of the superintending committee. Everything that is done there is done with my cognizance, and that of my colleagues. We are responsible.

11,219. At the time of the death of Admiral FitzRoy, it was found, as I have stated, that the funds originally voted for the purpose of these observations were diverted from their original scientific object to an object that was deemed of more immediate practical utility?—Yes.

11,220. Have both objects been subsequently kept in view?—They have.

11,221. The practical object has not been lost sight of?—No, it has not. Our endeavour has been, and is, to give such information, derived from watchful care over the facts, as shall enable those who may desire to do so to infer the probable weather from the present phenomena.

11,222. Colonel Strange informed the Commission that the objects which the Meteorological Office had in view might, in his opinion, be extended. Is it proposed to do so?—I have no doubt that they will be extended from year to year.

11,223. One of the objects was an increase in the number of stations, was it not?—We have seven stations in the British islands; the number originally designed was eight. As yet, we have no observatory north of Aberdeen. In ocean statistics there will be work for generations to come.

11,224. (*Dr. Sharpey.*) I think what Colonel Strange meant was, that a different class of work might be taken up, that is to say, original inquiries, such as inquiries into evaporation, and original experimental inquiries of other kinds. He said I think that the procedure was not experimental enough, and that it was too observational?—We are limited by the sum which is given to us. We cannot go beyond our funds. We do expend the sum placed at our disposal with as much care as we possibly can, but if more money were forthcoming and we had the power of directing the useful expenditure of it, we might do more. Were an application made to the Government for more money, they would possibly say that they do already give very liberally; and, in fact, they do give very liberally.

11,225. (*Chairman.*) But if more funds were placed at your disposal, you could without difficulty apply them in useful meteorological researches?—Yes, ocean statistics are a large subject. In that branch of our inquiries we have to collect and systematise the results of pre-existing researches (in which there is very much to be done), as well as in organising fresh researches: we are doing much in both ways.

11,226. I think Colonel Strange specially refers to two objects which should be included, namely, the action of the sun, and the subject of atmospheric

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

electricity; do you think that those are objects which, with more money, you could satisfactorily include?—Such researches are in progress by different nations and observers, and also by ourselves.

11,227. Do you know what the expense of the department is?—The expense is 10,000*l.* a year.

11,228. Colonel Strange was asked by Dr. Sharpey, "I think you said that the work of the Meteorological Office is too purely observational, and not "sufficiently experimental;" and he answered "Yes." *Q.* "What description of experimental work do you "think they should carry on?"—*A.* "I will try to "illustrate that. I should say experiments, for "instance, on the humidity of the air and on evaporation. Experiments of that class, I think, are a "great deal wanted." Is that your opinion?—They are much wanted, and we have at this moment arrangements in progress under the Meteorological Committee for the trial of a very promising apparatus, devised by Mr. Whitehouse, for determinations of the state of the atmosphere in regard to humidity. The objection to the present apparatus is its occasional failure in frost. The trial will require a few months; especially including at least a portion of the next winter.

11,229. You would not think yourself justified, I suppose, in recommending the Government to incur a large outlay on this department?—We have no immediate intention of asking for more money, but if we wanted an additional 1,000*l.* for a special purpose, I have little doubt that we should obtain it.

11,230. Has this sum granted to the Meteorological Department not varied within the last few years?—It was originally decided to be 12,000*l.*, but it was reduced by the Conservatives when they came into office to 10,000*l.*, and we have had to cut our coat according to our cloth. We have never exceeded that sum.

11,231. Now is that a subject for which the Royal Society would consider itself justified in recommending to the Government a larger outlay to be made, if they thought it of very great importance?—If we desired an increase of the grant now made to the Meteorological Office, we should in the first instance address ourselves to the Department of the State under which we act.

11,232. That department is the Admiralty, is it not?—No, the Board of Trade.

11,233. Do you find any inconvenience arising from different branches of science being under different Government departments?—No. I am not sure that it is not an advantage, for more public men are thus made conversant with the working of science in certain specific modes. I think that, in general, science recommends itself to them by its working. There is great care taken in the expenditure of the public money, and I think the Government see that. I believe it is rather an advantage to science that its operation thus becomes well known to many members of the Government.

11,234. Are there never questions arising as to which department of the Government you should apply?—No, not so far as I am aware.

11,235. (*Dr. Sharpey.*) The services of the Meteorological Committee are quite gratuitous?—Quite so, certainly.

11,236. (*Chairman.*) Does the Committee consist of three members nominated by the Royal Society?—It consists of eight members so nominated.

11,237. Are there any other points connected with the Meteorological Office on which you think it would be desirable for you to make any observations?—None, I think.

11,238. The next subject to which you allude in the statement is the subject of dredging expeditions. On that subject also the Admiralty has received a recommendation from the President and Council of the Royal Society?—Yes.

11,239. Was that recommendation favourably received?—It was. The Government have always received favourably recommendations proceeding from the two principal scientific societies from whom they are accustomed to receive such recommendations, namely, the Royal Society and the British Association.

11,240. Are any expeditions at present being undertaken?—There is one preparing.

11,241. Are there any other directions in which you think the services of the Royal Navy might be employed for the purpose of forwarding science?—The Government is always ready to receive such applications, and I think very favourably disposed towards granting them. If a subject were first taken up in the Royal Society, or first in the British Association, it would in either case be acceded to by both those bodies, and probably a joint recommendation would be the result. There was a joint recommendation in the case of the magnetic researches. The Royal Society is the long established State-constituted body, while the British Association seeks the sanction of the country at large, and pleads the cause of science throughout the islands. The two combined are a great support to the Government in reference to the justification of their adoption of any recommendation. There is a great advantage in there being two bodies for such purposes. When there was but one it occasionally, perhaps, would not be quite so active as people at the time thought it should be. Such was the case at the time of the foundation of the British Association, but the Royal Society very speedily resumed its efficient habits, and the two societies act very well in concert. It may be that the one or the other may become less efficient at times, but it recovers.

11,242. Are you aware whether any of the other scientific societies are occasionally consulted by the Government on special subjects?—There is nothing to prevent its being done; for example, they would probably refer to the Society of Civil Engineers on many subjects that could not, with so much propriety, be referred to the British Association or the Royal Society.

11,243. (*Dr. Sharpey.*) To revert for a moment to the Meteorological Office, let me ask you if they extend their operations into Scotland?—Surely. We have two observatories in Scotland—Glasgow, and Aberdeen.

11,244. Are you aware of any representations having been made by the Scottish Meteorological Society for aid from the Government, or for a share of the grant that is now voted to the Meteorological Department of the Board of Trade?—Yes, and I think that the Scottish Meteorological Society has a reasonable claim on the consideration of Government, on account of the services which they render, in connexion with sanitary inquiries, and also in reference to agriculture and horticulture.

11,245. The Royal Society of Edinburgh receives 300*l.*, but I do not know that the Meteorological Society receives anything, does it?—Not yet, I believe.

11,246. The Meteorological Society of Scotland supplies materials to the Registrar-General of Scotland?—Yes.

11,247. Do they undertake work of a special character which is really not done by other bodies?—I believe that to be the case.

11,248. (*Sir J. Lubbock.*) It is not meteorology so much as sanitary work, is it?—Without doubt there is a connexion between meteorology and sanitary matters.

11,249. (*Dr. Sharpey.*) The Scottish Meteorological Society have a great many observing stations, have they not?—Yes, they have.

11,250. (*Sir J. Lubbock.*) But so far as meteorological observations are concerned, do you not think it is convenient that they should all be guided from one centre?—I do not myself see that any change is needed in this respect.

11,251. If I understand you rightly, you think that the claim of the Scottish Meteorological Society is not so much a meteorological as a sanitary claim?—I do.

11,252. (*Chairman.*) Does the Meteorological Office communicate with any private meteorological stations?—Not necessarily so.

11,253. I did not know whether there might be any

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

private establishments that you put yourselves in communication with?—We have frequent communications with other institutions, and individuals at home and abroad.

11,254. Do you record the results of any observations conducted by private institutions?—Not of observations in the United Kingdom.

11,255. (*Sir J. Lubbock.*) What is the nature of the observations made by the Scottish Meteorological Society?—The greater number, I believe, are made by gardeners in large noblemen's establishments in Scotland.

11,256. But those are meteorological observations, surely?—They include certain meteorological observations.

11,257. But I thought you expressed an opinion that meteorological observations, so far as they were paid for by the State, ought all to go through one central office?—I am not aware of having said so; certainly not in the connexion which appears to be here implied. I do not consider it necessary, or even desirable, that the observations in question should pass through the Meteorological Office of the Board of Trade.

11,258. (*Chairman.*) Your Department does not conduct any regular systematic observations on the fall of rain, does it?—Yes, we do.

11,259. Only, however, at certain stations?—Only at certain fixed stations.

11,260. (*Professor Huxley.*) I suppose that the observations made by gardeners and persons without proper means of observation would not be accepted by yourselves as having the kind of accuracy that you require for your purposes?—No, but they may be available for the purposes for which they are made.

11,261. But you could not incorporate those observations with your own results?—We should not think it expedient to do so.

11,262. (*Chairman.*) One or two witnesses have come before the Commission who have recommended a more systematic observation of the tides. Are you prepared to express any opinion on that subject?—I believe that there are persons who are better judges on the subject than I am.

11,263. You would not, perhaps, wish to state whether that could be combined with the duties of the Meteorological Office?—I think it would be better done under the Board of Admiralty, who are very competent to direct or superintend such inquries.

11,264. Are there any other points on which you would like to make additions to your evidence? That is a large question. There are some things that I should be glad to see somewhat altered in our country. I should be glad, for instance, to see the British Museum made more extensively useful as a means of communicating knowledge throughout the country at large. The Trustees are under an Act of Parliament which forbids an object which has once entered into the British Museum from going out of its doors. Now it appears to me that it would be attended with great advantage if the British Museum were made the means of supplying local institutions with specimens under certain well considered regulations; the property remaining, of course, entirely in the British Museum, but admitting of being lent under careful regulations, and returned when reclaimed. I ventured in 1869 to make a suggestion to that effect to the Trustees, many of whom, I believe, were friendly to it, and an alteration has since taken place, I believe, whereby the British Museum is no longer bound to keep within its own doors everything that has been presented to it. That is the first step, of course, to any change of the kind suggested.

11,265. Do you think that the temporary loan of any object or specimen from the British Museum would be of much value?—Greatly so, as I learnt from persons very competent to judge. I shall be glad, if the Commissioners approve my doing so, to give in a copy of the paper which I drew up, and presented to the Trustees. The paper was as follows:—

"Memorandum, September 22nd, 1869.—It has frequently occurred to me that if the Trustees of the British Museum were empowered, by a slight change in the Act of Parliament constituting the trust, to introduce a new feature in its administration, they might be enabled, in full accordance with its principles, to add very largely to the public benefit of the Museum, without derogating in the least from the sacredness of their trust, and the due security of the objects confided to their care. I will only permit myself to speak of those objects of the Museum which, in one shape or other, belong to *natural history*, inasmuch as my place at the Board of Trustees is an official one, viz., as President of the chief and oldest British society, established by royal charter for the promotion of *natural knowledge*. I will suppose, therefore (to take an example in respect to birds), that, from among our very numerous and valuable duplicates, we were permitted to lend a limited portion or portions to our great cities and centres of population, the property continuing in the Museum, returnable either on requisition, or at the expiration of stated periods, when possibly they might be replaced by the loan of a differently selected collection. Careful catalogues should be formed and kept by both parties, and the best precautions taken for safety, both of transmission and custody. This might be done at first tentatively, in a single instance. Suppose, for example, that the great city of Manchester (including possibly its immediate neighbours) said to the Trustees, If you are willing, and if you can obtain permission from Parliament, will you, on our engaging to provide a suitable building, curators, and whatever else may be desirable, and also to provide all such other securities as may be required for their safe return, lend to us for a certain time from amongst your duplicates, say 'a collection of birds'? We should not ask you to make any new acquisitions on our account; if there were deficiencies which we wanted to have supplied, it would rest with ourselves to do so. The specimens lent by you would be seen by thousands and thousands who never even visit London; and real opportunities of viewing them at leisure and profiting thereby, would be afforded to hundreds of thousands more, while London would lose absolutely nothing, since all would be duplicates. Suppose this to be done in the case of Manchester, which might be the first applicant, and for a definite class of objects only, experience would soon show whether the plan might advantageously be continued, and extended more widely to other objects and to other places; and also in what respects the course first followed might be improved upon. A slight alteration in the Act of Parliament constituting the trust would seem to be all that is required. The leading object contemplated in this memorandum is, no doubt, the great enlargement of the national benefits derivable from the vast treasures contained in the British Museum; but collateral advantages of some importance might also be expected to follow from such a course of proceeding. More or less, and as far as it went, it would tend to relieve the museum itself of part of the immense mass of material by which it is daily becoming more and more oppressed; and might afford a corresponding degree of relief from the impending demand upon the public funds for new and greatly increased accommodation."

11,266. Do you propose that the plan should consist chiefly in the loan of duplicates?—Only of duplicates.

11,267. I think some of the officers of the British Museum have rather denied that there is such a thing as a duplicate?—If they opened their doors they would soon have duplicates in abundance.

11,268. I should have some doubt whether the loan of objects to museums in country towns would be of any material advantage, as probably what they would desire would be to keep permanent possession of them; is that your opinion?—It does not appear so. In discussing the subject in Manchester, where it was largely considered, it was found that they were very desirous of having such temporary loans, and of being allowed to change the specimens in, perhaps,

Gen. Sir E. Sabine, R.A., K.C.B., F.R.S.

10 May 1872.

five or seven years. Afterwards, the subject was discussed at Leeds, and they were very favourable to it, and exceedingly anxious that it should be carried out; also from Dublin there was a deputation to London on the subject. To all the applications that were made to the British Museum, the answer was, "By Act of Parliament we are bound to keep "within our own doors everything that we have, but "we should be very glad if that were altered." It does not appear from these replies that the Museum would be unwilling to lend specimens.

11,269. You have stated that this last year an alteration has taken place in that trust?—I have understood so.

11,270. Have any further steps been taken in the matter?—I do not know. By resigning my office as President of the Royal Society, I have ceased to be a Trustee of the British Museum. The present Chancellor of the Exchequer, Mr. Lowe, also a Trustee, was strongly in favour of the alteration. He was present when I brought the subject forward. It is obvious that such loans would require the appointment of persons as caretakers of the objects. If the persons so appointed to take charge of the collections were competent to give instruction in natural history, an additional advantage would be gained.

11,271. Do you think it would be desirable, generally, that museums should be teaching institutions?—I think it might be an advantage.

11,272. To a certain extent, I suppose?—Yes, to a certain extent; but the Commissioners will understand that this is not necessarily a part of the other suggestion.

11,273. Are there any other matters that you wish to refer to?—I am not aware of any.

11,274. If anything else occurs to you that you wish to place before the Commissioners, will you be kind enough to communicate it to the secretary?—I will do so. [*See* APPENDIX XI.]

The witness withdrew.

Adjourned to Wednesday, the 29th instant.

No. 6, Old Palace Yard, Westminster, Wednesday, 29th May 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

WILLIAM FROUDE, Esq., F.R.S., examined.

W. Froude, Esq., F.R.S.

29 May 1872.

11,274*a*. (*Chairman.*) I believe you were formerly professionally engaged as a civil engineer?—I was.

11,275. But you have ceased to act in that capacity for some time?—Yes.

11,276. You have given a good deal of attention to the subject of the advancement of science?—I have more or less. I have worked in my own narrow way in that direction.

11,277. Do you think that it is one of the functions of the Government to assist in promoting the advancement of science?—I think so, as far as I can judge, certainly.

11,278. Do you hold that opinion both with regard to questions of pure science, and with regard to matters that are likely to be of commercial value?—Yes; I do, certainly. It seems to me an object of national credit and national importance that scientific knowledge in this country should be advanced in both those departments to the highest degree, and, so far as I can judge, the nation values such advancement, and would approve its promotion by the Government.

11,279. Can you point out to the Commission the directions in which you consider that the Government can most properly render assistance?—It is a wide subject; I have chiefly pursued science myself in one department, in which improved scientific knowledge is of special money advantage to the Government.

11,280. Would you have the goodness to point out, in the first place, some instances in which you think that, merely with reference to the commercial value of such investigations, the assistance of the Government is desirable?—In questions of guns and gunnery, and of naval architecture in the construction of public works generally, it is of great pecuniary importance to Government that the most scientific methods should be pursued; and though these are more generally understood than formerly, the assistance of the highest scientific knowledge in the country would have been and would now be of immense pecuniary value.

11,281. What steps would you recommend that the Government should take in order to promote those objects?—That seems an extremely difficult question to answer, for a person who has but a limited experience; but it appears to me that there ought to be, certainly, some method in which the highest scientific knowledge of the country can make itself available, and make itself felt in all the departments of science which the Government ought to take cognizance of or to promote. At present the highest scientific knowledge in the country has no direct method of making itself felt; it can only make itself felt at rare intervals, when the Government has incidentally been led to call on it for assistance; and then it does not act as a constituted assemblage of the highest scientific knowledge, but only as one or two individuals who may have been invoked for the particular occasion when help has been wanted.

11,282. Are you acquainted with Colonel Strange's proposals for the advancement of science?—Yes, I have read them.

11,283. Do you agree with him that a scientific council, to give advice to the Government on questions of science, would be desirable?—I quite agree with him; but I think there might be very great difficulties in organizing it so as to act in the best manner possible.

11,284. Have you considered the constitution of such a council as was recommended by Colonel Strange?—I have considered it; but I really do not feel that my experience in the organization of such a body is of any value, or that I should like to pronounce any opinion as to whether the plan which he proposes is the best possible; but, so far as I could understand it and follow it, it seemed to me a very good proposal.

11,285. The main principle, as you are aware, was that every branch of science should be represented, at least, by one member, and that there should be also other elements; for instance, that the naval and military services should be represented?—Yes; but the difficulty, as it seems to me, is to make sure that you have the very best man in each department. It seems the essence of the thing that the very best knowledge that the country possesses should be available in the particular department to which it is applicable. I think, however, that such a body, if selected in the best

W. Froude, Esq., F.R.S.

29 May 1872.

manner, would know when to act and how to act almost without being called upon to act; and that it would be able to impress upon the Government and to impress upon the departments its own views. But I hardly know whether Colonel Strange recommended that the body should act *proprio motu* or merely when called upon. It seems to me that somehow *proprio motu* the best scientific knowledge ought to be able to make itself felt, and this in a manner analogous to what happens in other Government departments. In the law, for instance, there are some minor organisations for putting the law in force throughout the country; but their operation is somehow subject to, and liable to be acted upon by the highest legal knowledge that exists in the country; and, so far as science comes into the province of Government action, science ought to stand on the same footing.

11,286. Should you be disposed to think that the advice of such a council, representing, as it would do, every branch of science, would be of as much use for any particular object as the advice of a smaller body of persons conversant with the subject under consideration?—I think that in every department of the Government, if it is a department in which scientific knowledge is available and necessary, the head of the department ought to be possessed of a very high class of scientific knowledge; but I think there will always be occasions on which he would be glad to get the assistance of still higher knowledge. It would hardly be right to say that the Chief Constructor of the Navy, for instance, ought to be a man of the very highest scientific attainments in the country. If he has a general and proper knowledge of the scientific principles which his department requires, that might be sufficient; but, yet, he ought to be able to avail himself on extraordinary occasions of any higher scientific knowledge that is really applicable to his department. Therefore, I think that such a council would be of use, although its existence would not relieve the Government of the necessity of putting a very capable man in every department in which scientific knowledge is required.

11,287. According to Colonel Strange's proposal, it could hardly be expected that, on such a question as the construction of ships, the council would contain at the outside more than two or three persons who had paid special attention to that subject; but they would be persons of scientific eminence generally. Do you consider that the advice of such a council would be of great value?—I feel confident that it would.

11,288. And that the opinion of persons of scientific habits would be of value, even although they had not before attended to the particular question?—I think so. I think that a man of high mathematical attainments inevitably knows a great deal of the scientific principles directly bearing on questions of naval architecture, and that he would inevitably have long ago seen put into force principles that are now only gradually becoming accepted. Without being conversant with the actual construction of ships, he would have seen certain principles which ought to have been attended to, but which are only quite lately becoming attended to. No doubt there are always questions arising in which men of the highest scientific knowledge will be in advance of the practical knowledge of the day. Such a council would make it its business to feel its way as to the particular questions in reference to which its action would be of value, and would understand how to apply its knowledge. I think that the council would have to act with discretion in reference to the departments, because I found myself, for instance, last year, when I was sitting on the Committee on Designs for Ships of War, we were a large and somewhat miscellaneous committee, and a great many questions were asked by members of the committee which had to be answered by the constructor's department, and that department was worried out of its life almost by constant demands on its time in preparing reports on various questions, and many of those questions, I am satisfied, were questions which need not have been answered; so that the council would have to act with great discretion; but I think, if constituted as it might be, it would possess that discretion.

11,289. Was the committee of which you speak appointed by the Admiralty?—By Mr. Childers, as First Lord of the Admiralty, not long before he ceased to be First Lord of the Admiralty.

11,290. Was it solely to consider the question of the construction of ships?—To consider the designs of ships, either recently constructed or under construction, and to advise the Admiralty whether any and what modifications of design would be of value.

11,291. Did that committee consist of a large number of members?—I forget how many we were, but it was a large committee.

11,292. Were they all persons more or less conversant with naval matters?—Yes, many conversant with naval matters specially, one private shipbuilder of eminence, besides engineers, military, civil, and mechanical, and Sir William Thomson, all of whom had given attention to nautical questions. It took in a large class of experience, and was, I believe, on the whole, a very good committee; but still a large committee, acting in such a way with reference to a department, is very likely to wear out the department by demands on its time, when in many cases this might be better occupied.

11,293. You do not consider committees of that kind to be a very satisfactory way of proceeding?—I do not think so, because they have to find out the dream and the interpretation both, which is always a difficulty. They have to feel their way to a *locus standi*, which would already be possessed by a council habitually operating with reference to the subject.

11,294. Should you say that a scientific council, constituted in the manner we have been speaking of, would have been likely to act more satisfactorily?—Yes, I think so; that is to say, of course any council, beginning its work, would have a good deal of the same difficulty to go through, but a scientific committee, existing and habitually operating, would have got through that preliminary stage which such a committee, when freshly appointed, has to go through, and would feel its footing, and would know in what direction it wanted to operate.

11,295. Is this committee still in existence?—No.

11,296. Did it make a final report?—Yes, it made a final report.

11,297. And did it recommend any experiments or investigations?—Yes, it recommended some investigations, which I still have in hand. I have been continued in that position by the Admiralty; certain experiments as to conditions affecting the oscillation of ships in the sea-way I am still conducting.

11,298. Do you find the Admiralty disposed to render you all the assistance that you require in promoting those investigations?—Quite so; but, at the same time, I should have very much felt the value of such a council, had it existed, because I have been in rather an irresponsible position with regard to those experiments. I might have put the Admiralty to very great expense, or, from fear of running to too great an expense, I may be acting too timidly in particular cases. I should feel it of great value if I could apply to men of the highest scientific knowledge with reference to such questions.

11,299. May I ask whether the investigations which you consider desirable involve a large expense?—Frequently they involve very considerable expense. It is almost impossible to conduct experiments of that kind without large expense.

11,300. Do they involve the purchase of expensive apparatus of any kind?—Yes, they did so in this instance to some extent; but being a mechanic myself, and having a mechanic's shop, I have been able to save expense by preparing some of my own apparatus in a rough yet effective way, where, if a regular manufacturer had been applied to, it would have assumed an expensive character. But this, again, is one of the points on which men of the highest scientific attainments are the most successful. Sir William

Thomson, for instance, is most acute and ready in devising inexpensive instruments for the performance of experiments, which, in less able hands, would require costly apparatus, and in this way I have been materially assisted by him. I have another completely independent investigation in hand for the Admiralty, which was authorized by Mr. Childers, on Mr. Reed's recommendation, and for which a specific vote of 2,000*l*. was made, the object of which is to determine, by the use of good sized models, the best form for ships as governed by the resistance that they make in moving through the water with various speeds. And here again, as the conduct of the experiments is practically left to my discretion, I am in a sense irresponsible, and I should feel the value of having men of greater eminence to consult. For instance, I have found it of great value to have even casual and occasional discussions on the subject with Sir William Thomson and with Professor Rankine. Many new lines of thought are at once suggested by men of that stamp.

11,301. Are the two inquiries in which you are engaged quite distinct from each other?—They originated distinctly, although it is impossible to make them quite distinct. The one refers to the rolling of ships, and the other to their resistance; but, indeed, the determination of the resistance to motion through the water with a full-sized ship was one of the experiments that I undertook at the suggestion of the Committee.

11,302. You have no regular official colleagues in the inquiries in which you are at present engaged?—No. Officially I have to report, and I do report to to Dr. Woolley and the Constructor's department, but practically they leave me free to direct the course of the investigation, because, though no doubt themselves competent to direct it, they could only do this effectively by giving as much time and attention to it as I myself have to give, and their time is already laboriously occupied; whereas in the Council, if properly constituted, there would be men who could bring to bear a deeper insight into principles, and who could thus effectively and at once deal with any difficulty which might require solution.

11,303. You consider that the Chief Constructor requires some assistance of a scientific character?—I believe that under present circumstances his time must be so very heavily occupied by his ordinary work that it can hardly be possible for him to spare sufficient time and thought for the scientific investigation of new and difficult questions. The introduction of armour plating and very heavy artillery has not involved only great novelty and difficulty of constructive design, thus enlarging the ordinary labours of the office, but has also rendered necessary the solution of questions, in the treatment of which advanced scientific knowledge has been specially required.

11,304. (*Sir J. P. Kay-Shuttleworth.*) Are you aware whether there is any such scientific assistance in the department of the French Marine?—I believe there is. The French have been in many respects ahead of us in the science of naval architecture.

11,305. Did not the first step towards the formation of an iron-clad navy originate in France?—I have heard that the Emperor Napoleon was the first person to suggest the clothing of a ship with iron as a protection against shot, but I do not know whether that is so or not.

11,306. (*Chairman.*) I think I understood you to say that you had obtained valuable assistance from Sir William Thomson and Professor Rankine; their assistance has not been regularly called in by the Government?—It has not.

11,307. You have obtained it by private communication?—I have.

11,308. But you think it would be a great advantage to be able to appeal to a council containing such persons?—Yes; not only because I could appeal to them, but because such a council would have already had in its mind the lines of thought to be pursued; they would not have to think afresh about them. Although any able man at once does think well on such a subject, still it is a great advantage that he should have already been directing his attention specially that way, and Professor Rankine and Sir William Thomson both have done so.

11,309. Do you think that a regularly constituted body of advisers would be preferable to any advice obtained from time to time from a committee of scientific persons, such as the British Association is composed of?—I think so, far preferable.

11,310. Or the Royal Society?—Yes; I have not come across the Royal Society's committees, but I should think so. I think that any newly-constituted body, somewhat miscellaneously constituted as such a body is likely to be, has to feel its way, and is naturally less capable of giving immediate and serviceable advice. I have sat on several British Association committees, and I am on one now in which none of us are able to give full attention to the question, because we are otherwise fully occupied, and I have no doubt that the report will be either long deferred and probably imperfect in consequence. It is generally left to, perhaps, one member of the body to do the work, and then the rest join in the report with more or less intelligent interest and understanding of the subject.

11,311. Have any investigations of the kind been, to your knowledge, undertaken by any private shipbuilders?—No, I think not. I think that ship building, generally, has been very much carried on on traditionary principles, and I believe that even the best established scientific proportions relating to it are but scantily applied by men of the highest standing in the profession. I will give an instance of that:—Messrs. Laird Brothers, when they constructed the "Captain," had just gone through some ordinary calculations with reference to the stability of the ship, but with so little perception of the real nature of her novel features as to leave uncalculated the effect of those conditions on which the danger of the ship depended, so that the disaster which ultimately followed was not the least anticipated by them.

11,312. Have any considerable improvements in your opinion been introduced in ship building latterly?—Structurally very great, indeed throughout the work of the Constructor's department, attention to its scientific principles has in recent years become systematic. But I must add, the advance thus made appears to me not quite so complete in relation to the application of the principles which govern the rolling of ships; they do not seem to me to have been quite scientifically applied even in the ships that have been most recently constructed.

11,313. Do you distinctly hold that no progress in the application of science to ship building is to be expected except through Government action?—No, I would not say that. I think, on the contrary, that in the Constructor's department the scientific knowledge which has made such great advances in the last 10 or 12 years, will continue to increase.

11,314. I wanted to know whether you thought it essential to the application of science to ship building that Government should render its assistance?—I think not altogether, but great improvements must thus be introduced; I think so, because the Government is obliged to build ships of the very largest class, and it has at length begun to see that to put scientific men into the constructive department is essentially necessary. There is a very large class of naval architects being educated now in thoroughly scientific principles, and, in fact, the present constructors in the department are men of considerable scientific knowledge, I mean those in the Government employ, and, therefore, the Government does necessarily advance scientific ship-building by following out its own work in a scientific manner. It has begun to appreciate that scientific knowledge is necessary in naval construction.

11,315. Are the Government constructors all persons who have received a good scientific education?

W. Froude, Esq., F.R.S.

29 May 1872.

—I think they have. I think that there is a race of men growing up who are receiving a still better education. The School of Naval Architecture at South Kensington has produced some very well educated men. I have an assistant at present with me who was educated there, who has a very competent knowledge indeed of the science of naval architecture.

11,316. (*Professor Smith.*) You stated, I think, that a grant of 2,000*l.* had been made for your experiments on the relation of form to speed and resistance; it was for that class of experiments alone?—Yes; and, in fact, I have spent rather more than that money already, although the experiments have not very far advanced.

11,317. Do you consider that amount sufficient for the purpose of such a class of experiments?—I had hoped it would prove sufficient, but I find it is not, and I have just received an intimation from the Admiralty that they are prepared to extend the grant.

11,318. May I venture to ask whether your own services are remunerated in the matter?—No; but I may say that they are so indirectly to some extent, because a son of mine, who is clever and a good mechanic, and understands the question thoroughly, is employed by me as an assistant, and he is paid 150*l.* a year. That I put into my programme as part of what I proposed, and, therefore, I have no scruple in adopting that arrangement, but my own services are quite gratuitous: I am, however, thoroughly glad to give them, the matter is of such extreme interest to me. It is a great demand upon my time, but I am very glad indeed to give the time.

11,319. But as a general principle, you would hardly say that the Government, any more than a private individual, ought to have the services of a scientific man without paying?—Certainly, I agree to that entirely; I may say that the value of such services, when rightly applied, enormously outruns any possible expenditure that they may involve. The cost of that single disaster, the loss of the "Captain," exceeds immeasurably any kind of expenditure that could be devoted to the improvement of science as applied to naval architecture. I feel sure that if there had been, four or five years ago, a council such as has been proposed, that disaster would have been impossible. As it was, Mr. Reed's strongly urged objections to the ship, though based on scientific grounds, were overborne by ideas which relied simply on seamanship and traditionary knowledge.

11,320. (*Dr. Sharpey.*) If Mr. Reed could have strengthened his opinion by an appeal to a scientific council, do you think that the Government would have yielded?—I think so.

11,321. Was there not a great deal of outside pressure applied to the Government in the shape of public opinion?—Yes, in Parliament especially. Captain Coles had many friends; he was a very able seaman, and he had the faculty of inducing people to believe in him, and it was then believed that his practical knowledge as a seaman enabled him to judge of questions which were entirely beyond the cognizance of mere practical seamanship.

11,322. Do you think that the Government might have successfully resisted that Parliamentary pressure if there had been a responsible council to refer to?—I think so, certainly. But I think that the Admiralty itself was swayed by the same considerations as swayed Parliament, and they would have been much less likely to be so swayed if the highest scientific knowledge in the country had warned them of the danger.

11,323. Two views have been offered to the Commission with reference to the constitution of a consulting scientific council: one is that it should consist of a very large body, some 40 or 50, the members of it being, one or other of them, specially acquainted with almost every department of science and its applications; and the other view is that it should be a smaller body of some five or six men of high attainments in science, and of tried judgment, who, although not, perhaps, able to report of their own knowledge upon every specific point, could direct enquiries to be made, and judge of the result of those enquiries in advising the Government in a particular case. Have you ever thought which would be the most desirable plan?—I have thought about it; it depends upon how many branches there are in which the most advanced knowledge is essential to the due appreciation of what is to be done in that department.

11,324. It has been feared on the one hand that even with a very large council professing to be specially acquainted with almost every branch of science, questions would occur in which they would require to go outside; for example, you might not have been upon such a council, and yet they probably would have required to apply to you for information upon the matter which you are now investigating?—I should think that such a council would always have to direct investigations to be made.

11,325. In that case would it be needful to have such a large council; would not a smaller body be able to direct inquiries, and also form a judgment upon the results?—I should rather be inclined to think so; but my own knowledge of science is in a narrow groove, and I do not know exactly how completely the highest men at the very top of the tree may be regarded as omniscient in science; I mean equally conversant with the investigations which would be required in all directions of scientific knowledge, or whether there may not still be considerable sub-division in the highest area of scientific knowledge, so that a considerable number would be required on that score.

11,326. One consideration is, that the gentlemen on such a council would require to give up a large portion of time to their duties as councillors, and, of course, the nation would be called upon to make adequate remuneration for their services, and any practical proposal to be made to the Government would be more readily entertained if it recommended a moderately-sized council rather than a very large one?—Yes, this seems to me to be an extremely important question, but it wants greater experience and wider knowledge than I possess to offer any very distinct opinion about it, but I should have thought, as far as I know, that a numerous body would not be necessary. That would specially arise from the circumstance that eminent men would know in what direction further inquiries were needed, and would put them in motion, but then those inquiries would have to be paid for, so that a large expenditure is essential.

11,327. Do I understand you to say that the council would be able to form an opinion upon reports given by specially skilled enquirers, and advise the Government accordingly?—Quite so.

11,328. Are you quite satisfied with the operation of the present School of Naval Architecture?—I do not know very much of its operation. I only know its fruits, in the fact that a gentleman who is now acting as one of my assistants in my investigations, and who was educated there, has evidently been extremely well taught, and is not only well up in the mathematics of naval architecture, but in the common sense of the questions dealt with.

11,329. Of course, I need not say to you that the instruction there is, for a part of the year, systematic, and another part of the year it is practical in the dockyards?—Yes.

11,330. Do you approve of that?—Yes, I do, certainly.

11,331. You would carry both methods on *pari passu*?—Yes, certainly. When I was at Oxford such mathematical teaching as had nominal reference to practical questions was infinitely too divorced from practice. I had, in a sense, to unlearn my Oxford teaching, when I began my profession as an engineer, and to start afresh on a sounder basis of thought; and although, later in life, I found that the mathematics I had learnt were available, they had become very rusty.

11,332. You found, notwithstanding, a great advantage from that training?—Yes, I have found great

W. Froude, Esq., F.R.S.

29 May 1872.

advantage from it; and I ought not to be ungrateful for it.

11,333. (*Professor Smith.*) I think you said that in respect of the rolling of ships but little improvement had been made in the construction of ships?—I think that improvement has been made; but it has been made on only a partial appreciation of the true principles which govern rolling.

11,334. What I wanted to ask was, whether you think that it is likely that very considerable improvement can yet be made by the application of better scientific knowledge?—I think so. Indeed, I have now in hand for the Admiralty an experiment which they are enabling me to try on a large scale and in the most complete manner, and which I hope will show how a very great improvement in respect of rolling may be secured. The experiment only waits till we can have a good long Atlantic sea or regular rolling swell, having, as nearly as may be, the same period as the ships which are to be employed, so as to make the trial sufficiently severe, as well as quantitatively comparable in its results with those which would be theoretically expected.

11,335. So that you think that this is a matter in which it is not only a question of applying the scientific knowledge which is already possessed, but that much has still to be obtained on the subject?—Yes, I think that in the matter I refer to, such practical experimental investigation is what is chiefly wanted. Experiments on a small scale have satisfied me personally on the point, but in applying to a large scale the results of experiments on a small scale, there is almost always room for some doubt, and, at any rate, public opinion is much more easily satisfied by experiments on the scale of 12 inches to the foot than on a smaller scale.

11,336. Is the state of the question the same with regard to the form of ships in relation to their speed?—I think it is not exactly the same, because I believe that no *very* great improvements are to be made in form. There are a great many questions requiring careful investigation. I have reason to think that all the popular beliefs about the advantages of particular forms are mixed up with great error and misconception of the fundamental principles on which the question depends, and mistaken beliefs as to what really happens; but I think within certain limits the form of a ship is not so material as it has been considered; a particular form will do better at one speed, and another form at another; but still the differences are not nearly as large as have been conceived, and certainly many beliefs on the subject are distinctly erroneous.

11,337. (*Sir J. P. Kay-Shuttleworth.*) A scientific council would have two main characteristics, one would be the pre-eminent special knowledge of each of its constituent elements, and the other would be the greater power of scientific inquiry, and a knowledge of all the requisites of such inquiry; if very eminent men were selected, those characteristics might be obtained, might they not, in the very highest degree, in a small council?—I think so. The tendency of all scientific knowledge has been to run together towards one point, as far as I know. The principles which science recognises in all departments are gradually becoming fewer and more fundamental.

11,338. Supposing that six men, having in the highest known degree those pre-eminent qualifications for scientific investigation, were constituted the council of scientific advice for the Government, as a matter of course, they would be very capable indeed to select the special agents for particular investigations?—I think so.

11,339. They would first have a general knowledge of the persons most distinguished in every department of science, or the means of acquiring that knowledge, and selecting, therefore, the proper agency, and giving general instructions for the particular investigation?—Yes, I think so.

11,340. Regarding, therefore, that particular view of the characteristics of a pre-eminently qualified small council, do you not think that would probably be a sufficient first step to aid the Government?—I think that it would be better to begin with fewer eminent names than to begin with a large number, including men who are not perhaps quite so eminent.

11,341. (*Professor Stokes.*) In the conduct of experiments in Government departments, do you conceive that money is sometimes wasted by conducting them on a large scale, when the subject might be investigated, at least in the first instance, by experiments conducted on a small scale?—Certainly, I do think so most emphatically.

11,342. Do you think that civil engineers generally are acquainted with the principles according to which alone a model on a small scale, say a dynamical model, is a true model of what it is intended to represent where you have to deal with a different scale, not merely of length, but of time, and of weights, and of forces, and so forth?—I think that a great many civil engineers have not paid full attention to such subjects. I think there are some (Professor Rankine, I would instance) who are thoroughly conversant with such questions, and there may be many more, but I cannot cite them at the present moment; but I think that the general inclination amongst civil engineers who have not paid attention to the particular subject is rather to discountenance small scale trials, in the belief that they are extremely open to error; and so they are, unless the true principles of application are rightly considered.

11,343. Do you think that sometimes the full scale being preserved in one element and entirely abandoned in another, experiments are tried, sometimes, perhaps, to a considerable extent, which really represent, when properly interpreted, something that would be utterly preposterous in its application?—I think so. I may instance, if I have understood the question rightly, especially the application of models of ships as a means of investigating the best form to be used. It is essential that the model of a ship should be treated as regards resistance at a specialised speed appropriate to its dimensions, and the persons who, having tried models, have come to discountenance such trials as foolish, are ordinarily people who have tried a model at the same speed that a ship has been tried at, which is preposterous in the strictest sense of the term; but it is curious how widely spread that is. I have, indeed, seen extracts from a French work on naval architecture, in which sound views on this point are expressed; but the opposite view has been almost universally held. When a model is tried at the duly apportioned speeds (and I am satisfied that the true scale of speeds is that which I have suggested as the basis of the experiments I am trying for the Admiralty), the results, when properly analysed and reduced, are correct for the ship herself.

11,344. Do you think that there are other instances in which money is wasted for the want of a little scientific direction?—Yes; I think any experiment almost on the sailing or rolling properties of a big ship, when tried in a big ship to begin with, is a waste of money. The cost of construction of a big ship as an instrument of investigation is enormous; and if it is tried with a view to the application of a new principle, there must be the risk that the experiment will be to some extent wasted. Being an experiment, the very fact that it is an experiment implies that it may not turn out as it is expected, and a failure in so costly a piece of apparatus as a new complete ship is inevitably a very costly failure. So far as it is possible to arrive at a proper understanding of such subjects by small scale trials, it is of the utmost importance, economically, that that method should be adopted, and I think that that has not been sufficiently adopted.

11,345. And when experiments involving considerable expense are contemplated, do you think that it would be useful to submit them, in the first instance, to such a body of scientific persons as we have been speaking about?—Yes, I think so emphatically; in reference to such investigations it would be most important.

11,346. Do you think that they might suggest

W. Froude, Esq., F.R.S.

29 May 1872.

means whereby the results might be obtained at a smaller cost in some instances, and in others might prevent the expenditure of money in a manner which would be altogether foolish?—I think so.

11,347. (*Chairman.*) Do you think that experiments on a small scale with reference to naval architecture, if conducted with a due regard to scientific principles, would lead to as safe conclusions as experiments on a large scale?—In many questions they would, but of course discrimination has to be exercised.

11,348. Are there any other points connected with the advancement of science upon which you are prepared to speak, especially with reference to assistance from the Government?—I would say something in reference to the view that though Government is bound to promote scientific investigation for the improvement of its own particular work, yet in reference to those investigations in which success, if attained, would be highly remunerative, the prospect of success will secure the investigation. This no doubt often happens, but in such cases the first ventures are often ruinous, and this acts as a deterrent. In many cases, only firms of the highest standing could make the venture, and such firms, possessing already an established lucrative business, often hesitate to incur the danger of loss; perhaps, they are even more unwilling to risk the discredit of failure. I have known this to happen in reference to investigations, the results of which, if successful, would be of very great national value, and which eventually the Government will have to take up.

11,349. Are there any other matters upon which you would like to give the Commission some information?—I am not aware of any; I think that one of the things which one has to learn is to know what are the limits of what one knows. I always feel that it is very unwise to step out of the results of one's immediate experience.

11,350. Have you any other suggestions which you would wish to make with respect to the mode in which the Government might promote science?—Speaking from my own experience, I think I have said all that occurs to me to say. I think that if scientific advancement is made dependent upon the present haphazard method, it will be very slow and very incoherent, that is the general view which I have, and I have it distinctly.

11,351. It is only comparatively recently, I believe, that the question of the construction of ships has been considered to be a question of science at all?—Yes, that it has been in any true sense considered so, but I think that that sense is a very growing sense, and it is appreciated more and more, and no doubt more and more able men going into the department will make the department less and less dependent on what the suggested council would do; but still there would always be in the highest men of science a superior knowledge which would be from time to time applicable, and which ought to become applicable, in some very definite and certain manner.

11,352. (*Professor Smith.*) You have spoken, have you not, of the Constructor's department, as if it were rather overworked?—It has certainly seemed to me to be overworked. The mass of work that has to be got through is extremely heavy, and there is, besides, an immense deal of paper work and correspondence, and returns and reports on various questions are always being asked for; but I gathered this impression at a period when the committee was adding greatly to this latter sort of difficulty: still, it seems to me that the Constructor's department is so heavily occupied as to prevent any of its members from personally entering on any new investigation which involves time and labour, and unembarrassed thought.

11,353. (*Dr. Sharpey.*) You think that he should not be harassed with having to write reports and matters of that sort?—Just so.

The witness withdrew.

Adjourned to Friday next, at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 31st May 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
BERNHARD SAMUELSON, ESQ., M.P.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

BALFOUR STEWART, Esq., LL.D., F.R.S., examined.

11,354. (*Chairman.*) Will you be so good as to read to the Commissioners the paper which you have prepared containing your views on the present position of science in this country?—I have put as the heading of the paper four divisions. First, the present position of science in this country; secondly, this position requires to be amended, but this cannot be done by private means; thirdly, it ought to be done by Government; and, fourthly, suggestions as to what Government might do in order to advance science:—

"The means by which our scientific knowledge is advanced naturally divides itself into two branches, observation and experiment.

"The essential difference between these two branches is briefly this—in experiment we arrange our own conditions, while in observation we merely note the arrangements of nature.

"Thus, in astronomy we can only note what takes place, because, owing to the greatness of the field, we are utterly unable to influence the result; while again, in the study of living human beings, we must be guided, only for a different reason, almost entirely by observation, and very little by experiment. This inability on our part to control certain arrangements makes accurate records of all the results achieved by nature an object of very great importance, but more especially enhances the value of such records in those cases where nature works in an exceptional or unaccustomed manner.

"In the list of observational sciences we may embrace—

"(1.) *Astronomy*, denoting, by this term, all observations both of the position and of the structure of the heavenly bodies.

"(2.) *Terrestrial Meteorology* and *Magnetism*.

"(3.) Observations of the crust of the earth, embracing *Physical Geography, Geology, Mineralogy*.

"(4.) Observations connected with the appearance, habits, and structure of the various living beings that exist, or that have existed, on the earth, embracing *Natural History, Physiology, Palæontology*.

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

"(5.) Observations connected more especially with man, such as *statistics* and *history*.

"In the list of experimental sciences we may embrace—

"(1.) *Chemistry.*

"(2.) *Physics.*

"(3.) *Physiology*, to a certain extent, as far as regards animals.

"(4.) The same, to a much greater extent, as far as regards vegetable products, embracing *agriculture* and *acclimatization*.

"Having made this enumeration, I will now state what I know regarding the present position of these various branches of science in this country.

"ASTRONOMY.

"I am not competent to say much about observational astronomy of the ordinary description. From all accounts the Greenwich Observatory is an exceedingly good institution, as regards this branch of science. Astronomy is a great favourite with amateurs, and very good observations are taken throughout the country in private observatories; nevertheless, there is a general complaint of want of system, several observers working over the very same field, while other most important observations are comparatively neglected.

"Of late years photography and spectrum analysis together have enabled us to study with much precision the structure and general physics of the heavenly bodies, and more especially of the sun; but as yet this most important branch of astronomy has been cultivated entirely by private enterprise, and has received no public recognition from Government, if we except the grants for observations during total eclipses. Photographs of the sun have been taken at the Kew Observatory, under the direction of Mr. Warren De la Rue, the cost of the process being chiefly defrayed by the Royal Society. Spectroscopic observations of the sun have been made by Mr. Lockyer at his private observatory. The observations at Kew began in February 1862 and ceased in February 1872, the Government Grant Committee of the Royal Society being unwilling to extend beyond this period the annual drain of 200*l*. upon their limited income. There is, at this present moment, no place either here or abroad of suitable climate, where regular photographs of the sun are taken. Photographs of the sun are taken at Wilna, in Russia, but the climate there is very unfavourable for such observations.

"Appended to this paper are two letters, addressed by myself and by Mr. J. N. Lockyer to Dr. Roscoe, Secretary of the British Association Committee for Science Organization.

"From these it will be seen that there is daily increasing evidence that terrestrial magnetism, terrestrial meteorology, and sun observations are intimately connected, and ought to be brought more together than they are.

"At present there is no provision for sun observations, either photographical or spectroscopical. It is most essential that some provision should be made without delay for such observations. There ought to be a central station where the sun is observed both photographically and spectroscopically, and one or two outlying stations connected with it in suitable climates, so that we may obtain a complete record (independent of weather) of all phenomena on the sun's surface.

"The actinic effect of the sun ought also to be obtained at all these stations. An instrument for this purpose has been devised by Dr. Roscoe, and will probably be adopted by the Russian observatories.

"TERRESTRIAL METEOROLOGY AND MAGNETISM.

"*Meteorological* observations with self-registering instruments are taken on a large scale by the Meteorological Committee of the Royal Society, the expense being defrayed by an annual grant from the Treasury of 10,000*l*.

"Observations, with self-recording instruments, are likewise taken at the Royal Observatory, Greenwich, and at the observatories at Oxford and Liverpool.

"By means of their self-recording instruments the Meteorological Committee register continuously the following elements:—

"1. The temperature of the air.
"2. The temperature of evaporation.
"3. The pressure of the air.
"4. The velocity of the wind.
"5. The direction of the wind.
"6. The rainfall.

"These registrations are taken at their stations at Kew, Falmouth, Stonyhurst, Glasgow, Aberdeen, Armagh, and Valencia.

"Every morning, at 8 a.m., observations of the barometer, thermometer, wind, and other elements of weather are made at certain coast stations both in Great Britain and on the Continent, and telegraphed to the Meteorological Committee. Then, should a gale be blowing, for instance, at the south-west coast of Ireland, a notice of the gale is forwarded to those parts that are likely to be visited by it. The principle that guides the Committee in sending what may be called storm warnings is, with their present knowledge, merely to telegraph actual facts, such as the presence of a gale elsewhere: some judgment, however, being used as to the parts to which this knowledge is conveyed.

"Thus, the observatory system of the Meteorological Committee is devised with the view of extending our knowledge of the meteorology of the British Isles; while the telegraph system is arranged more with the view of promptly sending information of storms elsewhere to those parts to which such information may be of practical importance.

"Besides land observations, the Meteorological Committee receive numerous meteorological logs kept by captains of mercantile vessels, as well as of several vessels in Her Majesty's navy, if I am not mistaken. They have been enabled, by means of these logs, to publish three valuable communications, namely—

"1. Charts of surface temperature, South Atlantic Ocean.

"2. Contributions to our knowledge of the meteorology of Cape Horn, and the west coast of South America.

"3. Currents and surface temperature of the North Atlantic Ocean from the equator to latitude 40° N. for each month of the year.

"The Committee also publish quarterly weather reports, in which fac-similes of the traces derived from their self-recording instruments are given, although on a very small scale.

"The Committee tabulate the hourly values of the various elements as recorded by their instruments, but they do not publish these hourly values. All that they publish in this way is—

"1. Monthly tables of thermometric and barometric means, maxima and minima, as well as of dry air and vapour pressure.

"2. Five-day means of dry and wet thermometers and of barometers.

"The self-recording instruments at the Royal Observatory, Greenwich, record the same elements as those of the Meteorological Committee, the only important additions being earth currents and atmospherical electricity. I believe that hourly tabulations are made at Greenwich from the records of these instruments, but the Astronomer Royal does not publish these hourly records.

"The self-recording instruments in the Radcliffe Observatory, Oxford, record the same elements as those of the Meteorological Committee, with the addition of the electricity of air, and hourly tabulations are made at the Radcliffe Observatory from the records of these instruments, but the observer does not publish these hourly records *in extenso*. Nevertheless the results obtained at this observatory, with respect

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

to wind, have been so judiciously summarized as to enable a Manchester meteorologist, Mr. Baxendell, to derive from them the law which regulates the diurnal variation of velocity and direction of the wind.

"In the Bidstone (Liverpool) Observatory, the velocity and direction of the wind are recorded continuously, and also the barometric pressure, by a very ingenious instrument that exhibits continuously, as well as on a very large scale, the fluctuations of atmospheric pressure. I do not know whether the hourly indications of these instruments are tabulated at Bidstone; at all events the observer does not publish these hourly records.

"Besides these meteorological results, derived from self-recording instruments, eye observations of the various elements are made at various stations, both of England and Scotland, for the purpose of the Registrar General of those countries. Those in England are, I believe, made and reduced under the superintendence of Mr. Glaisher, while those in Scotland are made by the Scottish Meteorological Society, and reduced by the Astronomer Royal for Scotland.

"Finally, observations of rainfall are made at a large number of stations throughout the kingdom, chiefly through the energy of Mr. G. J. Symons, aided by a small grant from the British Association.

"It may be taken for granted that, by the various agencies which I have now mentioned, a very considerable amount of observational knowledge is being collected as regards the meteorology of the British Isles. Yet there are various deficiencies in such information. The first of these is its incompleteness, for, with the exception of observations at Greenwich and Oxford, we have no records of atmospherical electricity of which I know, nor are there any scientific estimates made of the heating and actinic power of the sun's rays.

"The second defect is its want of homogeneity and system. For a trustworthy record of certain elements we must apply to the Meteorological Committee; but for a trustworthy record of rainfall throughout the country, we must apply to Mr. Symons, while for electricity we must apply to Greenwich and Oxford.

"The next point is one of great importance, and it is that none of the bodies who tabulate from the curves of self-recording instruments publish their tabulated values individually. For my own part, I think the system of reducing meteorological observations hitherto practised is quite defective, and requires to be replaced by a method more suited for the present position of the science; and, with respect to this point, I beg to append some suggestions of my own which were communicated to the Kew Committee, and published by the British Association."

REMARKS on METEOROLOGICAL REDUCTIONS, with especial Reference to the ELEMENT of VAPOUR. Communicated to the Kew Committee by BALFOUR STEWART.

It will be desirable to preface the method of reduction herein proposed by a few remarks on the objects contemplated in such reductions. These objects are twofold. In the first place, meteorological reductions may be pursued with the immediate object of acquiring information as to the climate of a place; or, secondly, they may be pursued with the immediate object of extending our knowledge of meteorology, regarded as a physical science.

Thus, for instance, a certain kind of reduction might be imagined to be of immediate practical benefit in determining whether a certain place might suit a certain class of persons or a certain class of plants, but yet it might not materially advance our knowledge of meteorology regarded as a physical science. But, on the other hand, all observations tending to advance our knowledge of meteorology are of undoubted practical benefit. The amount of vapour present in the air is without doubt a very important element of climate, inasmuch as this affects in a marked manner the skin of the human body and the leaves of plants; but I am not aware that it has yet been determined, by the joint action of naturalists and meteorologists, what is the precise physical function which expresses proportionally the effect of moisture upon animal and vegetable life. Is it simply relative humidity? or does not a given relative humidity at a high temperature have a different effect from that which it has when the temperature is low?

There is, in fact, an absence of information as to the precise physical formula which is wished by physiologists as expressing the effect of moisture upon organic life. On the other hand, physicists may be presumed to confine themselves to meteorology regarded as a physical science. It is in this latter aspect that I proceed to discuss the question.

Regarding meteorology, therefore, as a physical science, it is one of our objects to ascertain the distribution and laws of motion of the dry and wet components of our atmosphere; and it cannot be denied that we are at the present moment in very great ignorance of these laws.

With respect to the motion of our atmosphere, it cannot be anticipated that we shall ever possess the same sort of knowledge which astronomy gives us regarding the motions of the heavenly bodies; for, in the latter case, the identity of the object is not lost sight of, while in the former case it is clearly impossible to ascertain the motions of individual particles of air. Our inquiries into the distribution and motion of the elements of our atmosphere must, therefore, be pursued by that method which enables us to ascertain the distribution and motion of any other substance or product, with the individual components of which we find it impracticable to deal.

Suppose, for instance, we wish to ascertain the wealth of our country in grain or in spirits, and the distribution of this commodity over the earth's surface. We should first of all begin by taking the stock of the commodity corresponding to a given date: we should next keep a strict account of all the imports, and exports of the material, as well as of its home production and home consumption.

Now, if we have taken stock properly at first, and if our account of the imports, the exports, the production, and the consumption of our material is accurate and properly kept, it will obviously be unnecessary to take stock a second time. But if these accounts are not kept with sufficient accuracy, or if we suspect that our material leaves us by some secret channel which we wish to trace, it will clearly be necessary to take stock frequently; and thus a comparison of our various accounts may enable us to detect the place and circumstances of that secret transit which has hitherto escaped our observation.

Applying these principles to the vapour of our atmosphere, what we wish to know is the amount of the material present at any one station at any moment, and also the laws of its motion. It would appear that the best way of measuring the amount present at any moment is by ascertaining the *mass* of vapour present in a *cubic foot* of air, mass and volume being fundamental physical conceptions.

Next, with regard to the motion of the atmosphere, including its vaporous constituent, the method of coordinates suggested by Dr. Robinson would appear to be the natural way of arriving at this. Let us set up at a station two imaginary apertures, one facing north and south, and the other east and west, and gauge the mass of dry air and the mass of moisture that passes each of these openings in one hour; we shall by this means get the nearest attainable approach to the elements of motion of the atmospheric constituents from hour to hour. We shall not, however, obtain by this means a complete account of this motion, for we have at present no means of measuring its vertical component. This vertical component corresponds in fact to the secret channel in the illustration given above, which we must endeavour to detect by some indirect method. Another thing that ought to be determined is the production or consumption of the vaporous element of our atmosphere, as it passes from place to place. This might be done, could we keep an accurate account of the evaporation and the precipitation, the two processes by which this element is recruited and consumed. This would, however, be a very difficult observation.

Let us now recapitulate what information regarding moisture we can obtain from such complete meteorological observations as are at present made. We have—

(1.) The mass of vapour actually present at a station from hour to hour.

(2.) The mass that passes a station in one hour, going east and west.

(3.) The mass that passes a station in one hour, going north and south.

There is wanting—

(4.) The vertical component of the motion of vapour.

(5.) Its production or consumption as it passes from place to place.

These deficiencies may, however, be, to some extent, overcome by the following considerations:—

First, the atmosphere moves as a whole when it moves, the dry and moist air moving together; *secondly*, dry air is neither capable of production nor of consumption, but always remains constant in amount.

To illustrate this part of the subject, let it be supposed we wish to investigate the vertical motion of the atmosphere at a certain station. Make this station the imaginary centre of a circle, the circumference of which may be supposed to be studded with other stations at sufficiently frequent intervals, so that we can tell, hour by hour, how much dry air passes in towards the centre of the circle through its circumference, and also how much passes out.

Let us suppose that more is passing in than is passing out, or that the imports into the area of the circle are greater than the exports out of it. Now the dry air that passes in is incapable of production or of consumption, and hence the stock of the material at the central station, and in the area generally, ought to be on the increase, since we have imagined the imports to be greater than the exports. If, however, we ascertain from actual observation that the stock of dry air is diminishing instead of increasing, we may be sure that some is carried off by an upward current, which, of course, carries the moisture with the dry air.

So much for the vertical component; and in the next place, with regard to the production or consumption of aqueous vapour as it passes from place to place. Our consideration has hitherto been confined to *quantity;* let us now define what is meant by the *hygrometric quality* of the air. It may be represented by the following quotient:—

$$\frac{\text{mass of vapour in a cubic foot}}{\text{mass of air in a cubic foot}}.$$

Now this quotient can only alter by evaporation, by precipitation, or by mixture. This hygrometric quality of the air may perhaps be considered as a quality sufficiently constant to aid us in tracing the actual motion of air, just as we may make use of the element of saltness to trace the actual path of an oceanic current. But besides this aid, we may make use of it to enable us to tell the precipitation or evaporation. For instance, a very damp air, in passing over a very dry country, may be supposed to emerge less damp, having its hygrometric quality changed; or a very dry air, in passing over a very damp country, may be supposed to emerge less dry, having its quality changed in the opposite direction. Thus by actual observation of the quality of the air at the time of its reaching some particular tract of land or ocean, and at the time of its leaving it, we may possibly get much better observations of what goes on in the country, as far as this particular research is concerned, than if it were studded with gauges.

I should therefore suggest that meteorological observations should, by a system of reduction, be made to show—

(1.) The mass of dry air and of moisture in one cubic foot actually present at each station from hour to hour.

(2.) The mass of dry air and of moisture that passes each station, hour by hour, in two lines of direction at right angles to each other, namely, north and south and east and west.

When these hourly elements are obtained, they might for seasonal changes be reduced after the method of five-day means, or for the investigation of abrupt changes of weather, such as storms, they might be utilized in some other way.

Retaining the belief that meteorology ought to be treated as much as possible with the view, in the first place, of determining the actual motions of our atmosphere, and, in the next place, of assigning the cause of these, it is no doubt the greater movements of the atmosphere that will be indicated by five-day means. It ought, however to be remarked that the observations at any station are subject to the influence of locality, none, probably, more so than those of wind. It would appear that this influence ought to be eliminated before we can make any trustworthy *quantitative* deductions regarding the greater movements of our atmosphere. I should, however, imagine that the quality of the air, as herein indicated, may be made of immediate use in the study of storms.

It has been suggested by Mr. Meldrum, who expresses his concurrence with the above remarks, that, in addition to the five-day means indicated above, there might be given a brief epitome of the weather. Thus, for instance, "The wind blew from the N.E. at Kew from January 1st, 1 a.m., to January 4th, 3 p.m., in all 86 hours, at the average velocity of 16 miles an hour, with an average pressure of 30 inches, a temperature of 40° F., and an average hygrometric quality represented by ·075." The same remarks had previously occurred to myself, and Mr. Airy also has recently suggested the study of the meteorological phenomena of those periods during which the wind blows in the same direction.

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

And I also beg to append copies of letters on this subject which I received from the Astronomer Royal and from Sir William Thomson.

EXTRACT of LETTER from the ASTRONOMER ROYAL.

"Royal Observatory, Greenwich, London, S.E.
"MY DEAR SIR, October 7th, 1869.

"I HAVE read with much satisfaction the paper of your remarks on meteorological reductions, &c., especially with reference to vapour. I do hope that by going on thus you may make meteorology a science of causation, and raise it from its present contemptible state.

"I have often thought that much may be gained by ascertaining at what rate aqueous vapour disseminates itself through air, and should long ago have made experiments, but that I want a hygrometer of sufficient delicacy. I then thought of suggesting it to the Kew Committee. Your paper restores the interest in my old intention, and I think I shall write to Mr. Gassiot.

"I am, dear Sir, faithfully yours,
"Balfour Stewart, Esq. G. B. AIRY."

COPY of LETTER from Sir WILLIAM THOMSON.

Largs, Ayrshire,
"MY DEAR STEWART, October 25th, 1869.

"I HAVE carefully read your 'Remarks on Meteorological Reductions with especial reference to the Element of Vapour.' I believe the plan you propose is adapted to bring out information of the most valuable kind, from observations which, until reduced on some such plan, might be accumulated indefinitely without any practical benefit.

"I look forward hopefully to the application of the same method to atmospheric electricity, so that we may learn what has become of the electricity that was in the air over a certain district, when there has been a diminution of the terrestrial surface electrification; and whence has the electricity come, when there has been an increase?

"Yours very truly,
"WILLIAM THOMSON."

"It may, however, be imagined that I am prejudiced in supposing that the system of reduction hitherto much pursued by meteorologists is bad; but I think there cannot be two opinions as to the propriety of the individual observations made by observing bodies being readily accessible to men of science in general, so that each may have the opportunity of reducing these according to his own views. Indeed, it appears to me that a ready access to individual observations is to the meteorologist what a ready access to specimens is to the geologist or natural historian. In both cases the material requires to be handled by many hands besides those which have quarried it before its full value can be brought out.

"Two things would be necessary before men of science could be expected to make much use of such meteorological observations.

"In the first place, the observations ought to be very accessible, and, in the next place, there ought to be a fund to supply the expense incurred by the employment of computers by men of science in working out their researches.

"I know that these views are shared by Mr. Joseph Baxendell, a distinguished meteorologist, but who would, no doubt, have done much more for the science of meteorology had he received facilities for the reduction of observations. Mr. Baxendell was good enough to give me his co-operation in drawing out the letter to Professor Roscoe, which I beg to append to my evidence.

"These views are also shared by Mr. Buchan, the well-known secretary to the Scottish Meteorological Society, who writes as follows:—

"'There are many inquiries which cannot be satisfied with simple averages of several years' hourly values. Thus, the following of a constant through each year separately: the observations which bring about departures in the observed values from the calculated (or apparent) values of a constant, &c., will serve for my meaning. These and such points are of

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

the greater importance when it is considered that for some years to come we must be content with very rude approximations to true constants, and shall, therefore, require to specially guard against hasty assumptions. The published hourly values in figures furnish the protection against the mischievous effects of such hasty assumptions.

"' The actual number of the persons who would likely *now* use the hourly values if published is not of much importance, since the fruit of one man's work would *pro tanto* serve for all.

"' The publication of the hourly values would throw open many inquiries to scientific men, of which several of Baxendell's inquiries may be referred to in illustration.

"' If the Meteorological Committee continue to publish only averages, and not the actual figures of observation, the result will be disappointing, and I fear would be irreparable. The published curves give the facts continuously recorded; but it is needless to say that in this form they are practically useless in every inquiry into which number enters as an integrant part. I have spent much time in reducing some of the curves to figures, but the toil is greater than we or our children can, I fear, ever hope to be able to bear, even though struck with a monomania for curves and figures.

"' It would be a great boon if there were a fund which could be impartially and judiciously administered to assist in calculating, and in mere mechanical work. As it is at present, a vast amount of the most valuable brain power is wasted on servile work of the treadmill sort.

"' The points calling for consideration are the administrative body, and the method and time of distributing the fund, whether (1) before an inquiry is entered on, (2) while it is in progress, or (3) *after it has been completed.*'

" These views are also shared by Mr. G. V. Vernon, a well-known meteorologist of Manchester, who writes as follows:—

"' If observations are to be made they ought to be *reduced, printed,* and *published* without exception.

"' It is no used expecting that the various observatories, &c., are likely to reduce the observations and apply them to theoretical inquiries, as such is rarely the case, and in England exceptionally so.'

" I feel the want of some such aid myself, and I should consider it, under present circumstances, as a very serious matter, were I to undertake an observational research in meteorology.

" What has been said with respect to meteorology, applies with equal, if not greater, power to *magnetical* observations. Such observations are taken in the country by the aid of photography, at the Greenwich Observatory, the Kew Observatory, and the observatory of the Stonyhurst College. Until the original records of these establishments can be readily made use of by all men of science interested in the subject, I fear the result of their labours will be but limited.

" Before leaving the subject of meteorology and magnetism, it is necessary to remark that if the observations on these branches be merely confined to the British Isles, we shall reap comparatively little good. Before these branches of observational inquiry develope into true sciences, we must have observations not only in the British Isles, but throughout the globe. Our system should, therefore, admit of international extension and co-operation; and with regard to observations at sea it will be necessary to take measures to obtain information with respect to the less frequented oceanic regions, for the ocean being a highway, while we have very good information along the usual routes of vessels, we have little or none for those places which are unfrequented.

" Other Observational Sciences.

" If we come now to the observational sciences connected with the crust of the earth, such as *physical geography, geology, and mineralogy,* we find that there are extensive institutes of various kinds by which much information regarding these sciences is accumulated and distributed. The British Museum and the Geological Survey may be named as examples of such institutes, and much knowledge of geography is being added by means of the Geographical Society. The immediate practical importance of discoveries regarding the crust of the earth might serve to render these branches of knowledge less dependent than some others upon State support, and yet these are among the branches of observational inquiry which have received most support from the State.

" The same remarks apply to collections having reference to the living beings of the earth, such as those connected with *natural history* in its various branches. I do not make these remarks with the view of suggesting that these branches of science have received too much support from Government, far from it. Great good is done by the support received; but surely those branches of knowledge are especially entitled to support, the ultimate bearing of which upon the welfare of the nation, though acknowledged to be great, is less immediate, and, therefore, less easily perceived by the less intelligent portion of the community. An intelligent and conscientious administration ought more especially to foster those branches of knowledge which are undoubtedly of national importance, but which are not immediately and apparently connected with the acquisition of wealth.

" Referring now to *statistics,* considered as an observational science, there can be little doubt of its great importance, and of the necessity for its further development. For if one great object of the progress of knowledge be the amelioration of man's condition, it is surely of importance to ascertain, from time to time, how far this is accomplished, with the object, among others, of finding what are the drawbacks to its accomplishments. Sanitary science is in truth of the greatest importance, and may be very greatly advanced by a proper system of statistics. But in order to receive the full advantage which we may expect to reap from statistical inquiries, they must evidently be undertaken by Government acting in conjunction with their scientific advisers.

" Experimental Sciences.

" In *chemistry* there are various laboratories connected with the universities and colleges of the country in which chemical researches are made. These laboratories are presided over by eminent chemists who are almost universally required to do a great deal of teaching work. Besides this they cannot avoid practising chemistry as a profession; indeed, the support given by the chemical manufacturers of the country to such laboratories naturally implies a readiness in the presiding chemist to conduct analyses, to act as referee, or to engage in other work of a professional character.

" The time of such men of science is, therefore, very much occupied, and it is in most cases but a small portion of it which they can devote to original research.

" In all its branches the cultivation of chemistry is of national importance, and more especially is this the case with regard to metallurgy. An establishment on a large scale, in which experiments might be made on the properties of metals and alloys, is very much wanted. At present improvements in metallurgy are frequently made the subjects of patents, in other words, the advantage of the new process for a series of years accrues, not so much to the nation as to an individual. Nor can this be wondered at, for the nation does not, as a nation, encourage individual investigators, and consequently investigators cannot be expected to yield to the nation the fruits of their investigations.

" Were there a State agency to advance science, it might reasonably be expected that there would be discoveries of a certain class, such as chemical and metallurgical discoveries, the immediate benefit of which would at once be thrown open to the people.

B. Stewart, Esq., LL.D. F.R.S.

31 May 1872.

“ I do not mean to say that Government should interfere in the various arts : to quote the words of a writer in *Nature*, ‘ Legislative interference is uncalled ‘ for wherever natural laws are at work to perform ‘ the required objects. Such natural laws are in ‘ operation in all or nearly all of the arts and indus- ‘ tries of life. To meddle with carpenters, or brick- ‘ layers, or shoemakers, is entirely beyond the province ‘ of Government.’

“ Chemistry and metallurgy are, however, rather sciences than arts. No doubt they are sciences having immediate practical bearings, but if left to find their way in the market, they will be cultivated with especial reference to such practical bearings, and they will, to a corresponding extent, be dwarfed as sciences. The truly scientific chemist will find himself unable to escape from professional work, and when he has made a discovery there will be a great temptation for him to carry his discovery to market and work it out, rather than to continue his services as an explorer. If, however, Government were to extend its support to the most distinguished of such chemists, it would remove these drawbacks to their career, and would, at the same time, secure great advantages to the nation. The recent advances in spectrum analysis were made by German professors who received Government support, and their system of analysis was at once thrown open to the world. This is a case in exemplification of the system I advocate. I may state that gun cotton was likewise the discovery of a German chemist.

“ In one sense *physical* investigators are better off, and in another they are worse off than chemical investigators. They are better off in respect to time, for although physicists have generally to teach classes, yet physical science is not so much a profession as chemistry. On the other hand, while more of their time is left free, their income is curtailed from the same cause, and frequently they devote their spare time to supplement their income by work of a literary or other nature. The difference is chiefly that the chemist may supplement his income by professional work, the physicist by literary or other work, while, in both cases, comparatively little time can be given to original investigation.

“ This want of time tells with great force upon that class of physical problems that require great accuracy, and, therefore, much time, in their accomplishment. And, as the instruments required for this class of problems are generally expensive, and the physicist has frequently no means of procuring them, it is not surprising that such problems are not much cultivated in this country.

“ There are, however, connected with physics a class of problems that can only well be undertaken by an institution connected with Government. It has been remarked by Sir W. Thomson that there may be many properties of bodies of which we know little or nothing, because our knowledge of them can only be obtained through experiments involving long time. Nevertheless, such experiments may be of great national importance, having reference, for instance, to the durability and strength of materials.

“ Such experiments could only be well performed in a central building, built and supported by Government, and, therefore, possessing sufficient stability of tenure as well as stability of construction. Experiments requiring extreme precision and involving much expense, but nevertheless of great national importance, might also be made in such a building.

“ Experiments on electrical standards might be quoted as an example of a set of experiments started by the British Association, but not yet brought to a final conclusion by that body, inasmuch as such experiments, besides the stable fixtures and apparatus which they require, need also greater time and labour at the hands of men of science than they can easily give, unless they receive more support than they do at present.

“ I may mention likewise experiments on the carrying power of water in motion as of very great importance.

“ Finally, the subject of standard thermometers and barometers is one which might be very appropriately investigated in a central building supported by Government.

“ There would be other scientific uses of such a building : one of these would be that it might also afford facilities for experiment to those men of science who are not connected with any institution.

“ Another would be, that it would form an appropriate home, not only for the national standards of weight and measure, but for derived standards, such as those connected with electricity, temperature, and pressure of air. Experiments ought also to be made, from time to time, with a view of testing the constancy of these various standards.

“ Being the home of the standards, it might also serve as an appropriate place for a museum of instruments, as well as a place where scientific instruments are invented and improved, and where they are also verified and supplied to men of science.

“ To some extent this verification is pursued at the Kew Observatory, which is now in connexion with the Royal Society, but it is a labour of such importance that it can only be well pursued in a Government institution.

“ It cannot, however, be supposed that all the scientific experiments of the kingdom can be concentrated in such a building ; many of them will be performed in the laboratories attached to the various colleges of the kingdom.

“ Such labours of the various colleges might be encouraged by Government in the following manner :—

“ 1. By a fund intelligently and impartially administered, so that a man of science will have no difficulty in procuring the money required to purchase the apparatus necessary for his experiments.

“ 2. By the Government endowing professorships in such institutions in which the professor is *required* to teach and *expected* to advance science. Of course, a man cannot well be ordered to advance science. Evidence regarding the endowment of such professorships has already been given by Professors Greenwood and Roscoe.

“ If we now come to *physiology*, considered as an experimental science, I am not sure that there is such a thing as a good physiological laboratory in the kingdom, and I believe that a man of science wishing to devote himself to physiology will experience difficulties as great as one who wishes to devote himself to physics. Were the State to aid science, I should imagine that a physiological laboratory would be a great desideratum. There are very many questions connected with physiology (using the word in a wide sense) which are of very great importance, and which require for their solution the co-operation of men of science of various kinds. As illustrations of these, I may mention researches connected with those organic germs which it is believed are present in the atmosphere, and which are thought to occasion many of the diseases which afflict the human race.

“ Again, it is still a perplexing question what are the conditions favourable to the growth of plants. Sunlight, or, at least, certain rays of sunlight are indispensable ; carbonic acid is also indispensable, and also a certain amount of heat ; but beyond this bare fact the laws of this relation are quite unknown.

“ A third question relates to the effects of climate upon organised beings, and connected with this I may be allowed to quote the following paragraphs from an article which I communicated to *Nature* :—

“ ‘ It appears that the general term meteorology embraces two entirely distinct subjects, one of these having reference to physiology, while the other forms a branch of physical research. The object of the one is to study the connexion between atmospheric conditions and the health of such organisms (animal and vegetable) as are subject to these conditions ; while the other, or physical question, is particularly con-

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

cerned with the movements of the earth's atmosphere, and with the causes thereof.

" ' On both of these important branches we are in almost entire ignorance. With respect to the first, the amount of vapour present in the air is, without doubt, a very important element of the climate, inasmuch as this affects, in a marked manner, the skin of the human body and the leaves of plants; but I am not aware that it has yet been determined, by the joint action of naturalists and meteorologists, what is the precise physical function expressing proportionally the effect of moisture upon animal and vegetable life. Is it simply relative humidity, or does not a given relative humidity at a high temperature have a different effect from that which it has when the temperature is low?'

" I shall now proceed to show that the private associations at present existing are inadequate, of themselves, to promote science as it ought to be promoted.

" To show this it will only be necessary to refer to the recent actions of our two leading scientific bodies. In the first place, with respect to the Royal Society, that body defrayed, from a small annual allowance placed by Government in its hands, the cost of producing solar photographs at the Kew Observatory for the 10 years, beginning with 1862 and ending with 1872, to which I have already alluded.

" Again, in the correspondence which took place between the Board of Trade and the Royal Society, previous to the organization of the present Meteorological Office, it was asserted by the Royal Society, and acknowledged by the Government, that the organization and continued support of meteorological observatories were things beyond private means.

" Next, with regard to the British Association. the maintenance of Kew Observatory was provided for during a number of years by an annual grant from the British Association. But this body resigned their connexion with it in 1871, feeling that the annual grant of 600*l.* was too large a proportion of their income to devote to one particular class of problems. I ought to mention that the Kew Observatory is now supported by the munificence of Mr. J. P. Gassiot, and that it is under the scientific direction of a Committee of the Royal Society.

" Again, it is known that lately the British Association have taken great pains to form a set of electrical standards, and that they have completed their standard of electrical resistance, which is, I believe, now very generally adopted by electricians. There are other standards which are, however, not yet completed, and I rather think that the subject hangs fire because men of science, under the present system, are so much engaged that they cannot afford to devote the great amount of time, as well as thought, which would be necessary to the completion of delicate standards.

" Another task undertaken by the British Association has been to report, from time to time, on the progress of various branches of science, or of particular portions of such branches, but often they have had great difficulty in obtaining the information from those best qualified to give it, the time of such men being very much occupied in teaching and other pursuits.

" I have already stated that meteorology is one of those sciences which suffer most from the present state of things, inasmuch as men of science cannot easily procure the meteorological observations taken by the various institutions, while, again, there is no proper fund from which to obtain money for the routine labour of reducing such observations.

" All these instances concur in showing that the scientific men of the country, whether alone or associated with one another, have not sufficient money at their disposal to prosecute science as it ought to be prosecuted.

" I feel sure that by means of the aid of Government the progress of science might be much advanced in this country. Without pretending to be an authority on the subject of administration, I cannot help thinking that the idea of Colonel Strange, as embodied in his paper read before the Royal United Service Institution in May 1871, is the right one.

" It appears to me that if much is to be done, it must be done by a responsible department; in fact, there ought to be something analogous to a Ministry for scientific affairs.

" The minister of science would require to have around him a number of scientific advisers, who ought, I think, to be paid servants of the Government. I think that a body of unpaid scientific advisers would not answer well, even if it could be possible to obtain the gratuitous services of such a body. This council need not, however, be entirely a consultative one, for a scheme such as recommended would render necessary the erection of a physical observatory, and of chemical, physical, and other laboratories, the directors of which might form part, at least, of the members of such a council.

" The duties of such directors would be of a very responsible kind, and they would require to be supported by a thoroughly efficient staff. It might, in the first place, be expected that they should prepare, or cause to be prepared, reports from time to time regarding the state of the various branches of science entrusted to their charge—to map out, as it were, the present state of each science, and to indicate the directions in which our knowledge is deficient and requires to be extended.

" Then they themselves, in their investigations, would do something towards the extension or consolidation of knowledge, although, of course, other men of science, in the provinces, would likewise perform a very important part of this work.

" A good understanding between the cultivators of any science in the various provincial colleges and the central Government director would, of course, be a *sine quâ non.* Each might materially aid the other; the provincial man of science might aid the central director in drawing up his reports, while those reports would inform the provincial man of science of the position of his branch from time to time.

" Again, if the provincial man of science wished to undertake a certain research for which money was required, he should apply to the scientific department of Government, who ought to have the power of administering a considerable annual allowance for the purpose of such researches. The application would be discussed by the council, who would be able to know whether the applicant was a trustworthy observer, and whether the research was one of sufficient probable importance to warrant the expenditure of Government money. A fund of this kind would, in fact, be an extension of the Government Grant Fund of 1,000*l.* per annum now administered by the Royal Society, only it would be administered by the scientific advisers of Government. The directors of such institutions and their staff would also invent, improve, and verify instruments. They would also instruct observers, and afford facilities for investigations suggested by individuals unconnected with any institution.

" It may be said, if such directors have duties of such importance to perform, will it not cramp their own original investigations? No doubt, if they are not sufficiently helped by a staff, they will suffer in this respect; but if they are well supported, and their time not wholly taken up, they will not, I think, be in a bad position as far as regards original investigations. I have spoken to several distinguished discoverers on this point, and they have told me that from their personal experience they have found their inventive faculties most active when they have been well employed, and in fact rather busy. It may be that a great deal of leisure is as prejudicial to original research as none at all.

" I have elsewhere suggested the endowment of science professorships in the various colleges of the country, in which the professor is required to teach and expected to advance science. This is a system which I believe

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

works well in Germany: there, a good part of the income of the various science professors is derived from Government, and the professor has, under the system, sufficient encouragement and leisure to devote a large portion of his time to scientific research. I have before mentioned the discovery of gun cotton and the development of spectrum analysis as illustrations of the working out of this system.

" In such a system an enlarged number of men would naturally devote themselves to science as a profession, and thus the system would form the natural and crowning development of the present educational movement, in which we have the chief facts of science taught in the various elementary schools of the country.

" The gain to the nation by an organized aid to science of this kind would be very great.

" In the first place, experiments connected with the materials used in the army and navy would be rendered not only much more effective but much more economical.

" The metallurgical laboratory might be expected to extend our knowledge of metals and their combinations, and to throw open such knowledge to the public at large. A similar beneficial effect might be expected from the chemical laboratory.

" The physical observatory and the meteorological system working together, might be expected to render meteorology more a physical science, and possibly to discover new relations between the various bodies of our solar system.

" The physical laboratory might perfect standards of all kinds, invent and improve instruments, lend them out to others, verify them for others, and instruct others in their use.

It might accurately determine the most important " physical constants, detecting also such properties of matter as require long-continued experiments for their detection.

" In the physiological laboratory researches connected with organisms, climate, agriculture, &c., might be undertaken.

" Of course, in many of these researches several of the directors would require to co-operate.

Letter from Professor Balfour Stewart, F.R.S., to Professor Roscoe, F.R.S., Secretary of the Organization Committee of the British Association, on the question of Scientific Organization as regards Meteorology.

THE subject under the consideration of the Committee is a very extensive one, and I am not prepared at this moment to present anything like a complete statement of the subject; nevertheless there are two very pressing wants of observational science to which I think attention ought to be directed without delay, and which I therefore beg to bring before the Committee. The *first* of these refers to aid in meteorological investigations. There is, probably, no science which depends more for its progress upon the patient and laborious reduction and discussion of numerous and extensive series of observed facts than that of meteorology. Hundreds of valuable series of meteorological observations, some of them extending over long periods of years, have been made and published, at a great cost of both time and money; but hitherto no results have been obtained from them at all proportionate to the enormous outlay they have involved, the reason being that the close application and labour and expenditure of time required to carry out meteorological investigations are usually much greater than private individuals can afford to devote to them. It is, therefore, absolutely necessary for the interests of the science that State aid should be given to scientific men who are willing to undertake meteorological investigations of the nature of reductions, provided they can show that the objects they have in view are of sufficient importance to justify a moderate expenditure in endeavours to attain them, this aid to be given in the form of pecuniary grants, to defray the expense of engaging assistants to make such reductions and tabulations of observations and results, and such computations as the nature of the investigations may require. If proper representations were made to Government on this subject, there is little doubt that something would be done; for Government are at this moment largely subsidizing the observational part of meteorology.

It is, however, very evident that unless the facts so accumulated can be thrown open sufficiently to men of science, their use will be limited. In the establishment of the Meteorological Office, Government have virtually allowed that the proper maintenance of a sufficient number of observing-stations cannot be expected from private means; but they appear to have forgotten that it is also necessary to open up these observations to men of science, and to provide the necessary means for discussing them.

When it is considered that it is now an established fact that meteorological changes have more to do with the production of diseases and death than all other known causes, it will be apparent that, besides its uses for the purposes of navigation and in the operations of the agriculturist, a knowledge of the laws and principles of meteorological science has an important bearing upon the welfare of all classes of the community, and that, therefore, the advancement of meteorology ought to be an object of anxious solicitude to every civilized government.

The *second* point to which I would direct attention is the bearing of Solar Physics upon meteorology.

Recent investigations have increased the probability of a physical connexion between the condition of the sun's surface and the meteorology and magnetism of our globe.

In the first place we have the observations of Sir E. Sabine, which seem to indicate a connexion between sun-spots and magnetic disturbances, inasmuch as both phenomena are periodical, and have their maxima and minima at the same times.

On the other hand, the researches of Mr. Baxendell appear to indicate a relation between the daily wind-currents of the earth and its magnetism, and also between the earth's wind-currents and the state of the sun's surface.

In the last place, the researches of Messrs. De la Rue, Stewart, and Loewy, appear to indicate a connexion between the behaviour of sun-spots and the positions of the more prominent planets of our system. Whatever be the probability of the conclusions derived from these various researches, they at least show the wisdom of studying together for the future these various branches of observational science.

Now, while a good deal has been done of late years in extending meteorological and magnetical observations, very little has been done in the way of taking daily photographs of the sun's surface. Mr. Warren De la Rue has undertaken, since 1862, the charge of the Photoheliograph belonging to the Royal Society at the Kew Observatory; and the Royal Society have hitherto contributed yearly funds from the government-grant for the working of this instrument; but this annual grant from the Royal Society is about to expire. Unless, therefore, these solar autographs shall continue to be obtained at private expense, we shall, in February 1872, be without a single station, either in the British Isles or, as far as we know, in any favourable part of the earth's surface, from which anything approaching to a sufficiently regular production and discussion of sun-pictures is likely to proceed.

It has already been acknowledged by Government, in the formation of the Meteorological Board, that it is beyond the power of private liberality to maintain such regular and long-continued observations; we, therefore, trust that they will, once more, come forward and establish stations in which the sun's surface may be regularly mapped, and the positions and areas of sun-spots regularly measured.

Again, in connexion with these solar researches, it is of importance to know both the heating and actinic effects of our luminary, and how these vary, not only from hour to hour, but from day to day and from year to year.

No instrument has, however, yet been devised by which the heating effect can be conveniently registered. On the other hand, Dr. Roscoe has perfected his method of observing the actinic effect so as to make it automatic; and thus a series of hourly observations of this element of the sun's activity can be very easily obtained. This ought to be done at every station where the surface of the sun is mapped; and we understand that this plan of Dr. Roscoe's is about to be adopted in all Russian observatories. It would thus appear that we are now in a position to define with precision what ought to be done at a sun-station; and, as long as the sun-establishment at Kew lasts, observers may there receive instruction in solar photography through the courtesy of Mr. De la Rue.

They may also receive instruction in the art of measuring the areas and position of sun-spots through the same source; and, finally, Dr. Roscoe will be glad to give the necessary instruction in actinic observations.

It is hardly necessary to remark that the stations should be so selected as, taken together, to be independent of weather, and to be capable of giving at least one picture of the sun's disk every day without the chance of interruption. We know enough of the climate of various places to bring about this result; and in our dependencies, if not in

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

Great Britain, we have a sufficient area from which to choose our stations.

The influence of weather in causing blank days is particularly detrimental in solar research. In the observations lately reduced by Messrs. De la Rue, Stewart, and Loewy, it has been found that a good record of the behaviour of sun-spots, with regard to increase and diminution, as they pass across the disk, is of great value; but that owing to blank days, this record can only be obtained for half the whole number of spots observed, and even for this half in a more or less imperfect manner. And it is of so much greater importance to select the stations so as to obtain a continuous record, inasmuch as such observations are not like experiments which may be multiplied *ad libitum;* for here we are furnished in a year with a record of a certain number of sun-spots and no more; and it remains with us to make the best possible use of the limited information which nature gives us.

In fine it is believed that a daily record of the sun's surface, accompanied with a record of his actinic power, is, in the present state of science, of the greatest possible importance.

In the preceding remarks no allusion has been made to the establishment of regular spectroscopic observations of the sun's disk; not because it is considered unimportant, but because it forms a separate branch of inquiry, which will be best reported upon by Messrs. Janssen and Lockyer, and by Dr. Huggins, gentlemen who have especially devoted themselves to this subject.

LETTER from J. NORMAN LOCKYER, F.R.S., to Dr. ROSCOE, F.R.S. Secretary of the ORGANIZATION COMMITTEE of the BRITISH ASSOCIATION on the "ESTABLISHMENT of REGULAR SPECTROSCOPIC OBSERVATIONS of the SUN'S DISK."

The following are some among the secular inquiries which, in my opinion, ought to be undertaken at once on a perfectly definite basis and with unswerving regularity. Of course I have not named all the secular inquiries, nor have I alluded to any of the special ones which are suggested almost every time one looks at the sun. These must be provided for, of course, but the great thing is *not to lose time in starting the work in which time plays the most important part.* I think the future will show that, in its broad outline, this work is as follows:

a. OBSERVATIONS ON THE JANSSEN-LOCKYER METHOD.

Prominences at limb:
1. Number.
2. Position on sun, with reference to spots and faculæ.
3. Height and brilliancy.
4. Materials.
5. Currents, direction, and velocity.
6. Thickness of lines at top and bottom.

Prominences on sun:
7. Number.
8. Position (as above).
9. Materials.
10. Rate of elevation or depression.
10A. Width of lozenge.
11. Thickness and brilliancy of lines and associated bright lines in spectrum of photosphere.

Spots:
12. Lines thickened.
13. Thickness of lines.
14. Alterations of wave length.
15. Variations of spectrum near spots, including bright lines.

Faculæ:
16. Thinning and disappearance of lines.
17. Bright photospheric lines.

b. OBSERVATIONS ON KIRCHHOFF'S METHOD.

18. Map frequently suspected regions of spectrum to detect changes in Fraunhofer lines.
19. Determine accurately every three or six months the thickness of the principal Fraunhofer lines.
20. Note changes in bright lines.

If the Committee wish I shall be happy to state at length the reasons which have led me to consider these observations as of high importance and of a secular nature. I may at once, however, very briefly point out, seeing that observations of the spots are considered valuable on all hands, that as the prominences occur in regions where the pressure is less than at the spot level, they will be likely to afford better indications of the fact of solar forces being at work; and as there is reason to believe that they are connected with the spots, we shall get more complete evidence in the same direction as that given by the spots. But we may get very much more than this. We now know that the sun's atmosphere extends 10′ at least above the spot level; we may, therefore, hope in this way to catch shorter periods than the sun spot periods. Again, the spectroscope takes us beyond the fact of *forces being at work.* The bright prominences and the lozenges seen on the sun itself, the thickening of lines in spots, and the alterations of wave length, are unmistakable evidences of what is going on; we get an idea of what forces are at work. But spots are not alone in question.

I say a few words with reference to some of the proposed lines of observation.

Prominences at Limb.

1. This is clearly necessary. We must have a prominence curve as well as a sun spot one.

2. In this way we shall be able to do for prominences what Carrington has done for the distribution of the spot in latitude, and in time settle another question about which there is much contradictory assertion among foreign observers at present.

3. For this, perhaps, C and brilliancy at base should be universally adopted. It will doubtless prove of much importance ultimately to keep to the division of prominences I have proposed in a paper communicated to the Royal Society.

4. Some one line in the case of each element must be taken and kept to. These observations have already given me much evidence of this kind—

$$\begin{array}{l} a \\ a+b \\ a+b+c \\ a+b+c+d \end{array}$$

and the series should be extended as far as possible. The structure of the solar and stellar atmospheres cannot be got at in a more convenient manner than this at present; and, as the lines indicate the vapours above the highest level of the photosphere, we may look for secular changes.

6. I have already evidence, I think, of change since 1868.

Prominences on Sun.

7, 8, 9, 10, 11. These observations are complementary to those made at the limb.

12, 13. I have already detected changes which are probably connected with the sun spot period.

18, 19, 20. I have already detected changes.

I think these observations should be made over one of 11 year periods, under absolutely the same conditions, with the same eyes and instruments, if possible; and even after that time I would rather extend the programme than alter it. The value of each observation will be increased by each additional similar observation.

Of course I expect the chemical end of the spectrum to be photographed. Rutherford and Cornu have shown this to be perfectly feasible in the case of 18, 19, 20. I believe that time and money are alone wanted to do part of all I have put down by photography. It will be an immense gain if this can be done from F, for the region between F and G is terribly trying for the eye. Up to F the eye must naturally be depended on.

Of associated work there will be such researches as explain to us what the various phenomena mean; measures of solar diameter; photographs of sun spots on a large scale; and eye observations with a fine instrument to determine whether the changes I have pointed out in the spectra and appearance of sun spots, are connected with the sun spot period.

I hope my accidental connexion with the new method of work will not cause me to be considered presumptuous if I state my opinion, that if it is considered necessary to study the sun the fountain of all our energies—at all, whether for practical ends or for higher objects, the method of local spectroscopic observation must not be neglected. I further believe, as I have before stated, that it helps us where nothing else does, even if the photosphere be alone considered, and that as we have above the photosphere a region of greater delicacy, the continued study of this will lead us far beyond the point we could hope to attain by merely observing the spots.

While I hold these opinions most strongly, I must also add that I see no way of having the work done by private effort. I have tried hard to continue the work, and in the fact that it was begun in this country by myself I had the strongest inducement to carry it on, but nothing short of one's whole time will suffice for such inquiries.

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

11,355. (*Dr. Sharpey.*) How far are you yourself cognisant of the fact that the Government Grant Committee of the Royal Society were unwilling to extend the annual drain of 200*l.* for working the Kew photoheliograph?—I am not myself a member of the Government Grant Committee of the Royal Society, so that my knowledge of the fact is entirely unofficial.

11,356. You ought to know better than I do that it was, I think, contemplated by Mr. Warren De la Rue and yourself to come to a period with those observations at the end of 10 years, viz., in February 1872, and then to start on a new footing, and I think you yourself have mentioned that it would be advisable to connect them with meteorological and magnetical observations; was not that, rather than want of means, the reason for their discontinuance?—It was the case, no doubt, that when the observations began a longer period than 10 years was not contemplated. I am not prepared to say what led Mr. De la Rue to contemplate a period of this kind; possibly he thought that there would be a difficulty in obtaining money from the Government Grant Committee of the Royal Society for a longer period.

11,357. That is your inference, but I do not hear that he ever applied for more money?—He was certainly under the impression that they would not continue the grant.

11,358. But there was not any application made and refused?—No, I think not; he was under that impression, and perhaps that prevented him from making an application for a longer term.

11,359. (*Chairman.*) Do you know whether that grant of 200*l.* a year was found adequate for the purpose?—Hardly adequate; it required to be supplemented on several occasions by private funds from Mr. De la Rue himself. He contributed a good deal, especially to the publication of the preliminary papers.

11,360. (*Dr. Sharpey.*) Might not those observations be continued by receiving a grant directly from the Treasury?—Yes, they might be continued at Kew with the same instruments; I do not think that there is any objection to that.

11,361. Do you think it very important that they should not be interrupted?—I think it of great importance that such observations should not be interrupted. We have had considerable difficulty in uniting together our own series with the previous series of Mr. Carrington, on account of the interruption of the observations in the meantime.

11,362. (*Chairman.*) There have been already three or four months during which the observations have been entirely interrupted?—Yes; in fact they are stopped. There is now no place of suitable climate in the whole world, one may say, in which good photographic observations of the sun are being taken.

11,363. Is the climate of Kew well adapted for the purpose?—No, it is not so well adapted as some other climates might be, but still we get a good many good observational days throughout the year; on the average, perhaps, we get pictures for 200 days in the whole year.

11,364. (*Mr. Samuelson.*) Are those pictures being taken in foreign countries at the expense of foreign governments?—Pictures are taken at the expense of the Russian Government at Wilna, a station in Russia, but the climate of that station is not at all favourable; in fact, the late Observer at Wilna, in corresponding with Mr. De la Rue, mentioned how very unfavourable the climate was for taking continuous pictures. I believe that, with regard to foreign Governments, Professor Young of America has been authorised to found an observatory for the purpose of solar research at a considerable elevation, namely, 9,000 feet on the Rocky Mountains, and also that M. Janssen has received authority from the French Government to found an observatory for the same purpose.

11,365. (*Chairman.*) Is the Observatory at Kew provided with all the apparatus that is required for the proper conduct of those observations?—It has the old apparatus with which the series was taken. Mr. De la Rue now proposes making the optical power of the instrument somewhat better than it was, but still I fancy that, at the present moment, or after a very little time, the instrument will be available to continue the series of observations that were interrupted.

11,366. If the Government were disposed to undertake that those observations should be continued they could be continued at no very great additional expense beyond the 200*l.* a year that has previously been devoted to the purpose?—Yes, certainly. I should say that, in order to reduce these observations well, the expense might be between 300*l.* and 400*l.* a year. We required to be economical. In fact I myself devoted a great deal of time towards the necessary calculations.

11,367. Has anything been done in the way of publishing the results of those observations?—Certain preliminary results were published at the expense of Mr. De la Rue, and they formed papers which were privately distributed. After those preliminary results the Royal Society were good enough to allow the papers to appear in their Transactions, and they have since appeared either in their Transactions or in the Proceedings of the Royal Society.

11,368. (*Dr. Sharpey.*) Have they not distributed copies of the photographs to different scientific institutions and individuals?—Yes, six complete sets of photographs are being taken, which either have been or will be distributed to six of the most important scientific institutions in the world, I forget their names at present.

11,369. The expense of that is defrayed from part of the Government grant to the Royal Society?—It was defrayed by a particular grant; not the 200*l.*, but an additional grant.

11,370. (*Mr. Samuelson.*) You state that there is a grant from the Treasury of 10,000*l.* per annum for meteorological observations, and you say that those observations are incomplete; are they incomplete for want of funds, or are they incomplete because no system which appears to you to be satisfactory has been as yet adopted?—I fancy that in the first place the funds are wanting; if you wish to have a very complete set of observations and reductions, the funds are too small, but for my own part I do not think that the system of reductions which they have pursued is the best one. That is, however, only my own private opinion.

11,371. But the system which you consider would be complete would, in your opinion, require additional funds?—Yes, it would require additional funds, but not very much additional.

11,372. Assuming that there were a Government department having authority in matters of this kind, might you expect that they would arrive at the same conclusions on this and other subjects as would be arrived at by independent men of science, or would there not still be a difference of opinion likely to arise as to whether the best thing was really being done?—I think that with regard to the observations themselves that are to be made, there is very little difference of opinion in the meteorological world. We know now what the chief kinds of self-registering instruments are, and what the chief elements of observations are. With regard to the method of reducing those observations, there may, however, be a considerable difference in opinion between scientific men; but if an observational establishment does not publish the individual observations, then men of science who might wish to reduce them in another way than they are reduced by that observational body, have not the opportunity of doing so, except by paying, at great expense, for manuscript copies of the observations to the office.

11,373. Then the difficulty at present is, that the observations, after they are made, are not published so as to be accessible to scientific men?—That is the difficulty.

11,374. In order to remove that difficulty some extra expense might be incurred?—Yes.

11,375 But it would not be necessary, in order to

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

obtain those publications, that there should be a special department of the Government?—No, but after individual observations had been obtained by a man of science, he would require to have a certain fund to aid in obtaining computers to calculate the observations according to his system, unless he was willing to devote a great deal of his own valuable time to computations.

11,376. Then we should still be landed in the same difficulty as to what ought to be done with those observations, that is to say, if his mode of computation were different from that of the Government department, he would still have to make his own computations, or he would have to give up his views and accept the Government scientific view, if I may so express it?—I should imagine that the chief function, in that way, of the Government would be to make the observations and publish them individually, and also to afford facilities to well known men of science to discuss the observations from different points of view. It appears to me that good results are more likely to be obtained if the observations are discussed from a great many different points of view by the general body of scientific men, than if they are only discussed by the particular man or committee of men who at the same time keep the observations going.

11,377. And for that reason you ask, in the evidence which you have already given, that the Government should do two things, in the first place that they should establish a council of men, who should not be merely advisers, but observers, of course at the expense of the country, and that it should also assist scientific men, not being members of that council, to make their own reductions?—Yes, certainly.

11,378. Then the question arises whether this great central body of observers would not tend rather to overshadow the lesser scientific lights; might it not rather disgust them with what they are doing in consequence of the great weight of the means which would be placed at the disposal of the central body, as compared with any of those outsiders who, although men of great learning and science, would certainly be working at a disadvantage?—I have already mentioned in my evidence that it is a *sine qua non* that there should be a good understanding between a central council of that kind and the scientific men in the various provinces. To take, for example, the question of observations, if it is imagined that the duty of the central establishment is not so much to generalise as to keep the observations going and print the individual observations, then they themselves are just upon the same footing as any outsider. No doubt it would be quite open to one of the council to reduce his own observations himself, but at the same time by means of some fund impartially administered any man of science in the provinces might have an equal opportunity of having the observations reduced according to his view, provided that he was a trustworthy man of science and well known to the public.

11,379. With regard to this necessity, which you admit, of a good understanding between scientific men and the central council of men of science, I would ask you whether, with your knowledge of human nature and your knowledge of the habits of thought of scientific men, you think that the good understanding would or would not be likely to exist?—I think that the complete publication of all their proceedings, and their complete responsibility to the Government, would go a great way towards enforcing the policy, at any rate, of such an understanding being kept up. Perhaps, too, the Council would not necessarily be composed of men residing in London, but might contain, with advantage, a proportion of men resident in the provinces, who were willing to come to London in order to be present at the meetings of the Council.

11,380. So that, upon the whole, you do not think that the danger of individuals being oppressed by the weight of this great paid central body would be a great one?—Not if there were sufficient publicity. No doubt the danger indicated in the question is, perhaps, a danger that strikes one as most likely to happen, but I think that in science, as well as in government and in other instances, sufficient publicity would go a great way to remove the chances of such influence of the council proving prejudicial.

11,381. Do you think that the public is sufficiently well informed to be able to judge whether the central council was acting fairly in these matters, or not?—Yes, I think that the scientific public are sufficiently well informed.

11,382. And do you think that the general public, who have to find the money, would be ready to be guided by the scientific public as to what was right and what was wrong in these matters?—I think that the general public as yet require to be more educated than they are in the matter of science, and at the end of the observations which I made at the beginning of my examination I mentioned that this proposed scientific organisation would form the natural complement to the education movement which is going on with regard to instruction in science at the present moment.

11,383. So that you are not prepared to say that the time has come as yet for carrying out such an organisation as you propose?—I think that the time has come for carrying out such an organisation, but with regard to this remote danger of a good understanding not existing between the central board and the men of science in the provinces, or of the one set of men oppressing the other, I conceive that some years after this, when the scientific public of this country shall have been more instructed, that danger might be entirely removed. I do not think, however, so far as I can see, that the danger is sufficiently great to render it inadvisable to initiate the organisation which I advocate.

11,384. I should like to call your attention to a case which is not entirely parallel, but which is somewhat analogous, and that is the case of architecture. I would wish to remind you of the present state of the discussions with respect to two very important buildings, the one being the Law Courts and the other the completion of St. Paul's Cathedral, and I should feel much obliged if you would point out to the Commission what reason you have for expecting better rrsults in reference to science than the squabbles which are going on in reference to a mixed question of science and art, like that of the architecture of our great buildings?—I suppose that, in some respects, those squabbles may be considered a sign of life. I do not know the present position of the question with regard to St. Paul's, but I fancy that the mere fact that the thing has been published and taken up by the public will tend to put matters right to a very great extent.

11,385. May I take it that you would rather see the central department and outsiders squabbling, than that they were doing nothing at all?—Yes, I would.

11,386. (*Professor Huxley.*) Is there not this great difference between the two cases, that in matters of science there is a demonstration of what is true and false, whereas in the question of architecture there is none?—I think that there is that difference.

11,387. (*Mr. Samuelson.*) But the similarity being still preserved so far that the general public do not know what is true and what is false?—The general public are not the judges; of course you will always have an amount of ignorance in the public.

11,388. What is the experience of foreign countries as regards the effect of Government interference in the advancement of science; is it, or is it not, to bring about sluggishness on the part of individuals?—I do not know that I have sufficient knowledge of what takes place abroad to answer that question as I ought to answer it, but I know something about what is taking place in Germany, and from all accounts the position of science, especially of those branches of science with which I am connected, is very much better in Germany than it is here, and the career of a man of science in Germany is a better one than it is in this country, and with regard to individual sluggishness I do not think the men of science in Germany have of late years shown themselves sluggish by

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

any means. Some of the most brilliant discoveries have emanated from German men of science.

11,389. But is it the case, or not, that the moment the country attempts to afford direct encouragement to science, to a very great extent, individuals cease to do anything at all, or do so little as to be next door to nothing at all; are individuals doing as much relatively to science in Germany as they are in this country, apart from Government support?—I think, if you take the comparative size of the nations, you will find a greater per-centage of scientific activity in Germany than in this country. Dr. Frankland lately brought this thing to the test of figures, and he found that in Germany the per-centage of original papers produced by German chemists was greater than by the chemists in this country, taking the number of German chemists into account on the one side and the number of British chemists into account on the other, each German chemist, on an average, producing a larger amount of original scientific papers in one year than each British chemist.

11,390. But have we ascertained, at all, what the private societies of Germany are doing, as compared with the private societies of this country?—Judging from their published papers it is to be presumed that the best established societies are actively at work, and the calculation of Dr. Frankland was founded upon a comparison of the Chemical Society of Berlin with that of London, both being private societies.

11,391. But it is the case, is it not, that the private societies are active, notwithstanding what has been done by the Government?—I believe it is. I have heard of the activity of the private societies in Germany, as well as in England, and I referred above to the Berlin Chemical Society.

11,392. (*Dr. Sharpey.*) With reference to Mr. Samuelson's question, I think that in Germany the Government does not directly take up scientific investigations, or create establishments for such purposes, but it aids the Universities and other educational establishments throughout the country, and most of the great results in science that proceed from Germany have been through institutions connected with education?—Yes, they have.

11,393. There is no inducement, therefore, for men in those institutions to become idle in consequence of the Government undertaking investigations through their own agents; they are not the direct agents of the Government for conducting scientific investigations at all?—No, they are rather in the category of professors, endowed by the Government, which I advocate.

11,394. They receive maintenance from the Government, besides what they gain from the exercise of their duties as professors?—Yes, undoubtedly, if you refer to the fees; and I think that, in like manner, the different colleges and universities of this country ought to receive very considerable support from the Government as regards science, and in addition to the endowments of certain science professorships, I should think that, in certain cases, the expenses of buildings and scientific plant ought to be borne by the Government.

11,395. If I understand you rightly in respect of observational establishments maintained by the Government, you think that their chief function ought to be to obtain and publish correct data, which independent men of science may then make use of in their own way?—I think so. I think that ought to be their chief function. Of course I do not think that they ought to be prevented from reducing their own observations.

11,396. Therefore, those are duties upon which there can be little dispute, I presume?—Just so. At the present moment, according to the evidence before the Commission, there is no proper publication of the meteorological results of this country, or of the magnetic results.

11,397. And you desire that there should be a more extended publication of the actual data obtained, rather than mere reductions of them?—Yes, certainly.

11,398. Leaving it to independent inquirers to make use of those data?—Yes.

11,399. You have compared such data, in fact, with the specimens in a museum, which any one might employ?—Yes; but there is this difference, that as an observation is a thing made at a particular moment of time, if you lose that moment of time you lose the observation. With regard to anything that may be dug out of the crust of the earth, you have always the crust of the earth there, and you can always get it; but if you lose time in beginning a series of observations, the loss cannot be made good afterwards.

11,400. Do you think that such an establishment under the Government should chiefly be engaged with routine work that can always be carried on, so as to avoid the risk of the resources of the establishment remaining at any time unemployed?—I think that the main reason why certain branches of work ought to be taken up by the Government is, that they contain a long series of routine observations which would wear out the patience of any private individual, and I should think that the establishment of a faithful record and the publication of those observations would be their primary duty; but at the same time I can conceive, more especially in certain observational branches, that a great deal would depend upon the person who was the observer at the particular moment. There are certain branches of observations, as for instance, spectroscopic observations of the sun, which would particularly depend upon the observer.

11,401. (*Mr. Samuelson.*) Have you made any estimate as to the amount of money which would be required, in addition to the 10,000*l.* which is now granted, in order to place those observations upon what you would consider to be a proper footing? I think that meteorological observations ought to be followed in connexion with solar research and also with magnetism, whether in one or in different institutions I am not prepared to say. You are speaking now of meteorology alone, I presume.

11,402. I am speaking of the object for which the 10,000*l.* was granted?—For some time I was the secretary to the Meteorological Committee, but I am no longer so, and I do not know at present exactly how that money is laid out. I should be disposed to think that a comparatively small addition to the 10,000*l.*, say something like 2,000*l.* more, would do all that is requisite.

11,403. In the event of that small additional allowance being granted, I would ask you whether the management of that fund would be better in the hands of a Government council than in the hands of the Meteorological Committee of the Royal Society?—I think the direction of the office ought not to be in the hands of a superintending scientific board at all. I think that it ought to be in the hands of one individual, similar, for instance, to the Astronomer Royal, who does not merely obey the command of a superintending council, but who acts on his own responsibility.

11,404. In that case he would still be responsible to some one, and he would be responsible to the minister, who would be responsible to Parliament?—Yes, certainly.

11,405. Do you think that responsibility to a minister, taking into account all the exigencies of parliamentary government, would be better than a responsibility to a scientific body like a committee of the Royal Society?—The present constitution of the Meteorological Office is this:—there is a scientific director, Mr. Scott, who is not required to originate scientific problems himself, but to carry out problems originated by the Meteorological Committee, and in that respect he is a servant of the Meteorological Committee. It is the Meteorological Committee that devise the kind of things that are to be carried out, and he executes them, and he is more an executive officer who carries out their suggestions. Therefore, the question is whether the whole conduct of any particular scientific branch should be in the hands of a superintending committee such as the Meteorological Committee, or whether it should be under a single man, such as Mr. Airy, both the Meteorological Com-

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

mittee and Mr. Airy being, of course, the servants of the Government, and being responsible to the Government in some shape or other.

11,406. You prefer, in point of fact, to have a better man, with less superintendence?—I should prefer to have a man with less superintendence.

11,407. I suppose the fact of the matter would be, that if you had a good man under a Secretary of State, he would really be quite independent, because you would hardly expect much control of such a man from the Secretary of State?—Precisely so; a man would not take umbrage at the small amount of control that would be given by a parliamentary officer of that kind.

11,408. So that the authority of the Secretary of State would be more nominal than real in a matter of that sort?—Yes, more nominal than real, certainly. It would not be so offensive, nor would it go into details; at any rate, he would be left at liberty to use his own discretion to do what he considered best for the good of the office.

11,409. But the amount of money which he would require would depend very much upon his views as to what ought to be done?—Yes; I suppose it is the case with Mr. Airy at the present moment; to some extent it would depend upon his views, but still he would not have the power of the purse; he would be trammelled there.

11,410. Therefore, the position of things would be somewhat this, that, in point of fact, the Secretary of State would be pressed on the one hand by a powerful official, and on the other by the Chancellor of the Exchequer in the opposite direction, and that he himself would have very little to say in the matter?—I cannot tell. I do not sufficiently know how a thing of that kind would work, but I see no reason why it might not work harmoniously. If you look upon a human being as a machine, you cannot create a machine without friction.

11,411. But they would work harmoniously by somebody giving way, the person to give way probably being the unfortunate Secretary for the department?—Yes.

11,412. (*Dr. Sharpey.*) You are aware that the Royal Society have really no control whatever over the Meteorological Committee of the Board of Trade?—I am quite aware of that.

11,413. They are in no way responsible to the Royal Society, they make no reports to the Royal Society, and the Royal Society have nothing to do with the expenditure of the grant?—Yes, I am quite aware of all that.

11,414. They merely name them just as a patron would name the incumbent of a living, and then he has nothing further to do with it.—Quite so.

11,415. (*Sir J. P. Kay-Shuttleworth.*) Are you aware of any injurious, benumbing influences upon private observations or investigations exercised by any of the departments which now receive grants from the Government, as, for example, on astronomical observation by the Observatory at Greenwich?—I think that the present Observer of Greenwich, Mr. Airy, is no doubt a most valuable servant of the Government, but he is now a man of considerable years, and probably in science, as in other things, a man is naturally more attached to the state of science in his younger days than to the state of science in his older days. I am not prepared to say that Mr. Airy has not sometimes appeared to me to have been detrimental to the development of certain branches of science.

11,416. But I mean with respect to the action of private observers and astronomers in the country: has the existence of the Royal Observatory at Greenwich to any considerable extent benumbed private enterprise in astronomical research?—No, I think not. Mr. Airy has always shown himself a very decided patron to private astronomers and private observations, and he has welcomed them heartily.

11,417. Taking another scientific department which receives grants from the Government, as, for example, the Meteorological, are you aware of any prejudicial influence which has originated with the grants to the Meteorological Department, in preventing meteorological observations and researches by private individuals?—No, not in preventing meteorological observations and researches by private individuals. They have no power which can be exercised over private individuals.

11,418. The intention of my question is this:—has the grant made by the Government to that particular department had the effect of preventing private observations or private research? I am not aware that it has. I think that it has rather stimulated them, for the meteorological office encourage meteorological observations being made. They are willing to receive records, and to store up records of private observations, if they consider them trustworthy.

11,419. Are private observers and persons who undertake scientific research generally wealthy persons?—In this country, I believe, that men of wealth have come forward as patrons of science, and I need only mention the late and the present Lord Rosse, Mr. Warren de la Rue, Mr. Gassiot, and many others that I could name as examples of wealthy patrons of science, who take a hearty, intelligent interest in the progress of science itself, and at the same time lend their money to advance it.

11,420. What is the proportion of persons so gifted with wealth to the proportion of able men who are willing to give their time and capacities to observations and research?—I think that the proportion is so small that able men, and men competent to conduct research, suffer in this country from not having sufficient means at their disposal to proceed as they would like to do.

11,421. Do you anticipate, then, that if there were any intelligent centre for the distribution of a sufficient fund to persons having the requisite capacities for observation and research, but not having the means, the distribution of such a fund would have any benumbing influence upon original observation and research?—No, I should think quite the contrary; it would encourage it very much.

11,422. You would expect that it would have a stimulating effect?—I should expect so. In meteorology at the present moment a meteorologist can hardly do anything; he may wish very much to make certain reductions, but he has to pay a high price to get hold of original observations, and he has also to consume a great deal of his own time, or to pay for computers' time, in order to reduce those observations. It becomes a very laborious and costly thing for a private individual in this country to produce any research in meteorology.

11,423. As far as you are aware, the grant of 10,000*l.* to the Committee of the Royal Society has no such effect of benumbing observation and research, but rather of stimulating it?—It has had a stimulating effect.

11,424. Can you conceive that grant, even supposing it were confined to that body, could be considerably increased and administered with a purely beneficial effect to the progress of science in this country?—If there were a scientific council I should imagine it would be the natural body in such a case, still, judging from what the Royal Society has done, I think that their influence might be very beneficially extended, so as to have larger grants at their disposal. I am not a member of the Government Grant Committee myself, but I think that there is only one opinion with regard to the way in which that body have administered the small amount of funds that they have had at their disposal.

11,425. The intention of my question was purely abstract, and not intended to have any bearing upon the comparative merits of the Government Grant Committee of the Royal Society, and of any other body which might be constituted, but simply whether a competent body, having large funds committed to it, to be disposed of in a way similar to that of the fund which is confided to the Government Grant Committee, would be likely, by its operations, to benumb and discourage original observation and

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

research on the part of private individuals, or rather to stimulate and promote them?—I should say most decidedly to stimulate them.

11,426. If we were to enter into the question of what would be the best constitution of the body, your view would be that it should not be confided solely to a Minister of State, but rather that it should be administered with the advice of a council of the highest class of scientific men?—Precisely so.

11,427. You have no apprehension that the Government, if so advised by men of the highest scientific capacities, would be likely to operate so as to control science, and to fetter the operations of individuals, or to benumb and discourage original research and observation?—I think not. I think that the great desideratum is to put more means at the disposal of private individuals, and, of course, this must be done by some sort of administrative body.

11,428. You would recommend such a council as a collective high intelligence, directing resources, and having a knowledge of the best means of the application of these resources for observation and research throughout the country?—Yes, I think so.

11,429. (*Mr. Samuelson.*) Have you carefully considered whether the Government Grant Committee of the Royal Society is or is not the best body for the purpose of administering larger funds for the objects for which the 1,000*l.* are granted?—If there were a very large addition to the present endowment of 1,000*l.* a year, it would, of course, require a very great deal more of the time of the members to administer such a fund, and probably the members would not be willing to do it, unless they were paid for their advice. The principle of having a body of men gratuitously to undertake to do anything in such a department appears to me to be a wrong one. So far as my limited experience has gone, I think that it has told prejudicially to the interests of science. If things are considerably developed, and the administration becomes a large one, I think that people ought to be paid for the advice which they give.

11,430. You do not mean that the administration of the 1,000*l.* has not been what you think it ought to have been?—No, quite the contrary; I think it has been quite unexceptionable.

11,431. But you would not expect proportionate success from a larger fund, unless it were administered by a paid body?—I should not. I think that if the fund is very large, it should be administered by a paid body.

11,432. (*Chairman.*) That remark would apply, I presume, to a very considerable increase in the grant?—Yes.

11,433. But probably you would not consider that the Royal Society would have any difficulty in managing two or three or even five times the present amount?—I should not think so.

11,434. (*Mr. Samuelson.*) Do you think that they could employ two or three or five times that amount with advantage?—I should think they could very easily.

11,435. (*Chairman.*) Are you of opinion that the value of this annual grant of 10,000*l.* to the Meteorological Committee, is to a great degree lost from the want of the observations being sufficiently accessible?—I think so.

11,436. If it is worth while for the Government to give 10,000*l.* for what they get for it, it would be still more worth their while to give 12,000*l.* to get those results with certain additions?—Yes.

11,437. (*Mr. Samuelson.*) Are you of opinion that if the extra 2,000*l.* had been given, and if the administration had been in such a body as you suggest, the reduction of those observations would have been made as a matter of course?—Opportunity would be afforded by a system such as I advocate for men of science that are outsiders to employ such observations. At the present moment the only brain power taken advantage of, so far as reduction is concerned, is the brain power of the Meteorological Committee; but if those observations were readily accessible to men of science, we could take advantage of the brain power of all those men of science who were interested more particularly in meteorology, and that would throw open in that way the brain power of the country.

11,438. Do you think that if you had had a council such as you suggest, this publication would have taken place as a matter of course?—The suggestion that I made was that the chief duties of such an establishment should be to observe and publish regularly, and certainly if you have such an establishment, it ought to be one of their fundamental duties to publish regularly the observations that they have made.

11,439. Supposing that, instead of your advising it, the scientific council had had to advise, do you think, that, as a matter of course, they would have advised the Government to publish those observations?—I cannot answer that question.

11,440. (*Chairman.*) The committee of the Royal Society have published several of your meteorological reports, have they not?—Yes.

11,441. Have you any reason to suppose that they do not recognise the value of those publications which you think desirable?—I cannot exactly tell, but when I was secretary to the body, several members of the Meteorological Committee expressed themselves very highly in favour of a certain particular method of reduction which I myself advocated, and yet I did not receive sufficient encouragement to go on with that system.

11,442. (*Dr. Sharpey.*) Did you suggest the publication of individual results?—I believe I did; when I was secretary I suggested that among other things.

11,443. Was the want of funds given as a reason for not doing it?—I am not sure at what particular stage I suggested it. I believe that the publication of the meteorological results is done through the Government Printers, and I do not think that at the present moment the 10,000*l.* a year pays for the publication at all, and unless it might be considered too much to ask the Government Printers to undertake the publication of individual results, I do not see why that could not be done at the present moment; it would be a great boon to science if it were done.

11,444. (*Chairman.*) The expense of the publications that are issued does not come out of the 10,000*l.*?—I believe not. I believe that the expense of publication is borne by the Government Stationery Office.

11,445. (*Sir J. P. Kay-Shuttleworth.*) Probably in speaking of printing the results of the observations of the Meteorological Department, you would desire that a sufficient number of copies should be printed to enable them to be distributed to all the proper depositaries of scientific results in this country and abroad?—Yes, I should decidedly.

11,446. (*Chairman.*) You have pointed out, also, that, in your opinion, the observations conducted at those stations are incomplete in certain respects?—In certain respects they are incomplete.

11,447. If those additional observations were taken that you recommend, would much additional expense be incurred?—I do not think that much expense would be incurred.

11,448. Would any additional buildings be required?—No, I think not.

11,449. Or any addition to the staff?—Yes; I think that certain additions to the staff would be necessary; if, for instance, observations on the electricity of the air were to be taken generally by photography at seven stations, no doubt a certain additional outlay would be required, but I think that, altogether, the additional outlay would be comparatively small.

11,450. Do you think that those additional observations are not taken from the want of a sufficiency of funds, or is it that the importance of them is not generally recognised?—The Meteorological Committee at one time thought it was advisable to have observations with a self-recording electrometer, and, when I was Secretary, an instrument was got for the purpose, which was set up at Kew, and some little time was

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

spent in testing this instrument, and endeavouring to overcome some of its defects. That was more than two years ago now, and I am not aware what steps have been taken in the meantime. I think it is very likely that in the course of time the Meteorological Committee may do more than they have hitherto done with regard to the electricity of the air.

11,451. (*Professor Stokes.*) Do you think that a satisfactory instrument as yet exists for the purpose? —At Kew two years' observations were made with a self-recording electrometer, by Sir William Thomson, with a water jet, the difficulty being that during the time of frost the water got frozen in the pipe, and the pipe got broken, but with that exception that instrument worked extremely well. An instrument has been made since in which, instead of having a jet of water discharging itself into the air, a flame of gas is made to burn in the air, and with certain modifications this principle might probably render the instrument perfect. The only disadvantage appears to be that in times of great wind a flame of this kind is apt to go out, so that, as it were, we have to choose between an instrument that is out of order when there is frost, and an instrument that is out of order when there is wind; that seems to be the difficulty: so that I should not be disposed to blame the Meteorological Committee too much for not having a perfect self-recording instrument. A different system, no doubt, has been in operation at Greenwich and at the Radcliffe Observatory at Oxford, but I do not imagine that that system would be as good a one as Sir William Thomson's, if the preliminary difficulty could be overcome.

11,452. You stated that the self-recording instruments at the Royal Observatory at Greenwich record the same elements as those which the Meteorological Committee do; are the instruments so strictly of the same kind as to be comparable in their results?—I think that what the two sets of instruments are intended to get are very much the same, but the instruments of the Meteorological Committee are superior to those of the Observatory at Greenwich. The object to be attained by both sets of instruments appears to be the same, namely, the temperature of the air, the temperature of evaporation, the pressure of the air, the velocity and direction of the wind, and so on; but with the instruments adopted by the Meteorological Committee, as far as I can judge by the probable errors of observations, are better than at Greenwich.

11,453. Do you think that the difference between the instruments is such as to make it undesirable that the results obtained by the Greenwich observations should form part of the same system as those taken by instruments of the same pattern as those employed at Kew; or would it be desirable for the sake of strict comparison that all the observations included in the comparison should be taken with similar instruments? —I think that when once it has been determined that one set of instruments is better than another, for the sake of uniformity, and for the sake of obtaining the most accurate observations, the most perfect instrument should alone be adopted.

11,454. Supposing that the same instruments were employed at Greenwich and at the various meteorological stations, do you think it desirable that meteorological observation should be taken both at Greenwich and at Kew, or do you, on the other hand, think that that would involve waste?—I think that the present system [illegible] very much good done in attaching meteorological observation to the Observatory at Greenwich.

11,455. From the tenor of your answers I suppose you think it would be the more desirable of the two that the meteorological observation should remain at Kew than be attached to Greenwich?—I think that the Kew system of instruments is preferable to that of Greenwich. With regard to the present organisation of the Kew Observatory, the Kew Observatory at present has been administered by a Committee of the Royal Society. I do not even know who the members of the committee are, but I believe that they are the same as the Meteorological Committee. The instruments at Kew I should prefer for my own part to those at Greenwich.

11,456. Apart from the question of instruments, do you think it desirable, or the reverse, that the head of the astronomical observatory of the Kingdom should be charged with the additional duty of taking meteorological observations?—I think it undesirable that he should be charged with the addition of meteorological observations, because, first of all, the field of astronomy is so large, and altogether it is like taking on quite an additional branch of science, requiring a different system and having different traditions, if a science of that kind is attached to the astronomical observatory.

11,457. (*Professor Huxley.*) With regard to the Meteorological Committee, what is the relation of that committee to the old Kew Committee?—There is no relation between them, or rather the only relation was this, that the Meteorological Committee, with the consent of the old Kew Committee, adopted the Kew observatory as their central observatory, of course with the consent of the British Association, which was then the governing body of the old Kew Committee.

11,458. Then Kew is now actually an observing place of the Meteorological Committee?—It is.

11,459. You were an officer of the Kew Committee, were you not?—Yes, I was the Superintendent of the Kew observatory under the old Kew Committee.

11,460. Did you work under the Meteorological Committee?—I was Secretary to the Meteorological Committee.

11,461. Are you satisfied with the present organisation of that Committee?—No, I am not satisfied.

11,462. This is an institution which has been established by the Government for scientific purposes, and, therefore, it is very desirable that the Commission should hear what your judgment may be upon the organisation of that committee, what you consider to be its defects?—The defects are those I think which are incidental to an unpaid body of men. If you have an unpaid body of men that really are interested in science, and devote a very great amount of time to a particular subject, there seems a greater difficulty in calling them to account than if they are paid officers. I think that a body of men of that kind, supposing that the Government were to call them to account and to say, We are not pleased with this, might reply, We devote a great deal of our time to the interests of this office, and we are not paid anything for it, and it is very hard that we should be called in question.

11,463. Did you leave your office of Secretary because you were dissatisfied with the organisation of the committee?—Yes, to some extent I did.

11,464. I presume that you were the actual practical head of the establishment so far as the ordinary business was concerned?—I was of assistance to them in getting into existence and operation their self-recording instruments; but, as far as the business of the office was concerned, Mr. Scott, the Director, took charge of the business of the department. When I was the secretary, with the help of a mechanician, Mr. Beckley, I devised the construction of their meteorological instruments, and got them into operation. I think very few changes have been made since the instruments were devised; but as soon as the instruments came into operation, and it was found that they were accurate, and tabulations were taken from the instruments, then the next question before the committee was as to the method of the reduction of those observations. I brought forward certain views with regard to those reductions, and a member of the committee brought forward certain other views, and at that time there was a good deal of discussion about our different views; but ultimately my views were not adopted, and I did not receive sufficient encouragement even to try them in a preliminary way, because sufficient funds were not put at my disposal to give them what I considered a fair trial, and, altogether, there was a good deal of annoyance connected with the whole subject; and I left partly because I felt that my health was giving way under the strain and worry incidental to my position, in addition to the work which I was also doing with respect to science.

11,465. You speak of the Director, Mr. Scott; how was he related to the Secretary?—I think that the relation was an anomalous one, and I never have been able to understand it. He had charge of the correspondence of the office.

11,466. Had he any scientific charge of it?—Yes; he had also a certain amount of scientific charge, for instance, getting into operation the telegraph system, and telegraphing the results of storms to the different ports. He undertook that, and he carried it out very efficiently.

11,467. But he had no charge of the observations made at the observatory?—None whatever, except that when the results of the observations were properly reduced in the Kew observatory, and were signed by myself, they came into the office, and after they came into the office they were of course in his custody.

11,468. But, in point of fact, what may be called the scientific work of the observatory was in your hands?—Yes.

11,469. Do you think that the work would have been better carried out if you had been in the same position as Mr. Airy, that is to say, with an adviser, possibly in the shape of a board of visitors, but not being directly controlled by the Committee?—I think that it would have been better carried out by a Director in the position of Mr. Airy than by the present Committee.

11,470. (*Mr. Samuelson.*) Supposing you had been controlled by a Government council such as the one you propose, rather than by such a committee as you had, do you think that that would have been any improvement of your position?—I think it would, because on a Government council of that kind there are only one or two to represent a particular branch of science. A Government council such as I have advocated would not control a man in his own branch. There are certain questions which might arise in which one branch of science was connected with another branch of science, and in that case very rightly the advice of the whole council would be a matter of some importance; but if, for instance, you had a council of that kind, and one of the officers of this council was a director of a meteorological observatory, no doubt he would be the chief authority on meteorology there, and the other members of the council would not try to control him as far as his own branch was concerned. Certain questions might arise involving the joint operation of several of those branches, and in that case any individual member might be controlled by the whole council; but in that case I imagine he would not be controlled by the council in the same way that the officers of the Meteorological Committee were controlled by that committee.

11,471. Then, in point of fact, your council would be a sort of board, composed of the heads of departments?—Yes.

11,472. (*Chairman.*) Do you see any strong objection that might be taken to throwing open the records of the magnetical establishments to be made use of by men of science?—I see none whatever. It would involve a little additional labour; but men of science, I have no doubt, would be glad to pay for the labour of doing it.

11,473. (*Mr. Samuelson.*) What becomes of them now?—I do not know. I suppose they are preserved in the archives of the different establishments.

11,474. (*Professor Smith.*) Are they not accessible to persons who wish to examine them?—I do not know whether in all cases copies of such observations might be obtained. At present there is a sub-committee of the British Association, who are making inquiries of the different observational establishments, with the view of ascertaining how far they are willing to throw open their records, and in all cases but one we have got replies from the observational establishments. We put questions to the Meteorological Office, to the Astronomer Royal, to the Kew observatory, and to the Stonyhurst observatory, with regard to their records, and we have got replies in all cases except one; and I suppose the reply from the remaining establishment will come very soon.

11,475. (*Mr. Samuelson.*) Are you at liberty to say what the nature of the replies is?—The nature of the reply received from the Astronomer Royal was very favourable. He is willing to do all he can to throw open his observations to the public, and the observer at Stonyhurst observatory is willing to do as much as he possibly can do. The Astronomer Royal may be able to do a great deal, but it is not very much that a private establishment can do in that way. Then with regard to the Meteorological Committee, they are willing to give copies of different observations on payment being made. We have not yet obtained any answer from the Kew observatory. (Since the date of the examination an answer has been obtained from the Kew Committee, who decline undertaking to present men of science with copies of their individual magnetic tabulations.)

11,476. (*Chairman.*) I see you state that you consider it to be of great importance that meteorological and magnetic observations should be made not only in the British Islands, but throughout the globe. How far is that the case at present?—In America lately they have done a good deal with regard to observations in the continent of America itself, and I think they have established a self-recording system of instruments in various places. And then, with regard to the sea, Admiral Maury and the late Admiral FitzRoy, and others, are well known as having got vessels to make meteorological logs, and so to have records of observations at sea preserved in this manner; but still there is this drawback, that those logs generally apply to those oceanic regions that are more particularly frequented by trading vessels, and that we have a deficiency of information from those regions that are comparatively unfrequented. I do not see that we shall ultimately obtain a proper account of the meteorology of the globe, until we have the means of obtaining a great deal more information from those comparatively unfrequented oceanic regions.

11,477. That information could only be supplied, as far as this country is concerned, by sending out special expeditions to those parts of the ocean?—Yes, and that might be in connexion with expeditions of another scientific nature, such as deep-sea dredgings, and things of that kind.

11,478. (*Dr. Sharpey.*) There are meteorological establishments in some of the colonies, in Mauritius, for example, are there not?—Yes; they have a Meteorological Society at Mauritius; there is also an observatory supported by the Government there, and at Bombay there is a magnetic and meteorological establishment, and at Calcutta there is a meteorological office, I suppose not very dissimilar in constitution to the Meteorological Office here.

11,479. (*Chairman.*) Is anything being done on the continent in those directions?—In Russia they are doing a good deal; they are extending their labours in that way. I believe they are going to make observations for ascertaining the actinic effects of the sun, on a self-registering system devised by Professor Roscoe, and in Holland they are doing a great deal too, and in France they have done a good deal.

11,480. What has been done in Russia or any other countries has not hitherto been strictly in co-operation with what has been done in this country?—No. I think that if meteorology is ever to develope itself into a science of the same order as astronomy, there must be some international action. We must really endeavour to know what are the great changes that take place in the atmosphere of our globe. At present our information is extremely defective, it is quite in its infancy as far as knowing what are the currents of the globe and what takes place in the upper region of the air. We have very little information that

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

the chief currents, such as the trades and anti-trades, but with that exception our knowledge is very limited.

11,481. Does the Meteorological Committee obtain copies of publications, or the results of observations in other countries?—Copies of the publications of results of large establishments in other countries are generally sent to the Meteorological Committee, and they have a library where they keep those results. I am not sure to what extent they have developed what may be called the system of exchange of periodicals. And then again they have a large number of meteorological logs, more especially from merchant vessels, that are sent in to them, and they encourage the system of merchant captains taking trustworthy logs. I think they give a reward to those who keep the best log, at least they mention them in some way.

11,482. (*Mr. Samuelson.*) With regard to geology, do you think it would be a proper application of the national funds to bore through the Permian strata in order to ascertain the existence or the reverse of coal over a wide area at great depths?—That is a question on which I do not know that I could give an answer. I am not sufficiently acquainted with the subject of geology, nor do I quite understand the question. Of course it is of very great importance to this country to know what amount of coal there is in the country, but I suppose that individual enterprise to a large extent enters into that question. A coal mine is a source of profit to those who possess the ground on which it is.

11,483. That is quite true, but the expense of such deep borings has been as yet quite unascertained, and the profit might accrue not altogether or perhaps not at all to the individual making it, but to a very large body of proprietors, and therefore the question arises whether it would not be a fit subject for state assistance?—Perhaps it might, but at the same time it is possible that those benefited would be those in a large area, and not throughout the whole country.

11,484. But still over a very large area, and if other similar explorations were made by which other areas again would be benefited, would or would not that be a proper extension of the Geological Survey?—I think certainly, so far as I am able to understand your question, it would be.

11,485. With regard to statistics, do you expect that much benefit would be derived to statistical observations from the establishment of a council, seeing that, in the first place, there are societies for the collection of statistics, and, in the second place, there is at the Local Government Board an officer of considerable authority, who is able to direct inquiries of that sort, and also that the registrar general collects statistics bearing upon public health and upon other questions of public importance?—I presume that if this new system were carried out, it would incorporate into itself some existing institutions, for instance, the Astronomer Royal with his institution, and those institutions that you speak of as recording statistics; and the advantage in that case would rather be that the statistician connected with this central board would come into contact with scientific men connected with other departments in an official or semi-official way, and they might all work harmoniously together. He might derive benefit in his own subjects from those directors or members of the council connected with other departments.

11,486. Such being already in some measure the case as regards private societies?—Quite so.

11,487. You look for one result of scientific investigations conducted under Government authority, namely, that discoveries would be thrown open which now become the subject of monopoly, but you are no doubt aware that it is processes rather than scientific discoveries that are the subjects of patents?—Yes, certainly.

11,488. So that a patent, which means a monopoly, could still be obtained and probably would still be obtained for a process after the discovery had been made, which was the foundation of the process?—Yes.

11,489. For instance, take a very notable case, that of the conversion of iron into steel by blowing in atmospheric air. I suppose it was not the discovery of Mr. Bessemer that carbon could be burnt out of iron by blowing air into it; but he was the first to apply that discovery to that practical purpose, and for that he obtained his patent. Assuming that the burning out of carbon by contact with air had been discovered by a body of scientific men under the Government, the monopoly of the practical application of that discovery would not have been prevented, would it?—No, still something I think would accrue to the public in that particular way. For instance, in a metallurgical laboratory it is just possible that a certain combination of metals of a superior kind might originate, and also certain processes of obtaining those metals, and those processes and results of different kinds would be thrown open to the public in cases where they might not otherwise be thrown open.

11,490. Then you would be unwilling that any person engaged in investigations of this sort should be allowed to take out a patent?—Yes, a patent on that point. He might, of course, take out a patent upon quite a different subject; but as to a patent connected with those very experiments that he was making for the Government, I should hardly imagine that it would be right that a man should take out a patent on his own account.

11,491. You are no doubt aware that persons employed in Government establishments have frequently taken out patents for the very subjects which it was their duty to operate upon?—Yes.

11,492. And that you consider not desirable?—I consider that it is not desirable. I should not consider it right.

11,493. Would you offer any encouragement in the way of reward for discoveries of that kind, not being rewards by way of monopoly?—Yes. A generous government certainly, if a man in its employment has made a very valuable discovery, and at once gives up all share in it, and all wish to patent it, ought to reward him to some extent.

11,494. Would you propose that it should be one of the functions of the scientific council to be judge in cases of that kind?—I have not thought of that particular point.

11,495. (*Professor Stokes.*) If I understand you rightly you do not propose to abolish the system of patents altogether, but only to prohibit persons from taking out a patent who have made researches in the Government establishments which lead to some process which is of a nature to be valuable in a pecuniary point of view?—I think so; a patent I mean with regard to that subject.

11,496. (*Mr. Samuelson.*) It would be a matter arising out of investigations which it was his duty to conduct?—Yes; of course he would be required to report those matters to the Government.

11,497. You state that it has been observed by Sir William Thomson that there may be many properties of bodies of which we know little or nothing, because our knowledge of them can only be obtained through experiments involving long time, and then you point out that nevertheless such experiments may be of great national importance; is there any reason why private societies, well established, should not conduct observations of that kind?—As far as the matter of tenure is concerned there might be no reason why they should not; but as far as the building is concerned I do not think that there is a building suitable for the purpose existing in this country at the present moment. If the Government wish to conduct such inquiries, and such inquiries are to be conducted in this country, the first thing would be to have a suitable building of a sufficiently solid construction, and, being in the hands of the Government, of sufficient stability of tenure as well as of construction. No doubt you might suppose experiments involving a long time to be undertaken by a professor at some college in some university, but the successor of that particular professor in that particular department might turn his attention to quite a different subject, and he might not continue the experiments that his predecessor had begun. There you have not a sufficient guarantee that experiments once begun shall be continued, and, of course, in such experiments the long continuance is everything.

11,498. Do you think that a Government council would be more likely to direct the continuance of such experiments than the authorities of a college or university?—I think if it were known that one of the great objects of such a council was to conduct experiments where a long time was required, once those experiments had begun they would consider it a matter of primary duty to keep the experiments going.

11,499. On the other hand, might it not be possible that the spirit of routine might induce them to conduct them, perhaps, rather longer than was necessary, having once been begun?—That is possible.

11,500. (*Chairman.*) Is the building which you contemplate in that part of your evidence something distinct from the laboratory to which you refer afterwards?—No, I think not; in fact it would form a part of the physical laboratory.

11,501. Those experiments could be conducted in the physical laboratory?—Yes.

11,502. (*Mr. Samuelson.*) You speak of the verification of standards being a labour of such importance that it can only well be pursued in a Government institution; are you aware what is the practice in other countries with regard to that?—I am not sure to what extent the thing has been developed in other countries, but in this country, to some extent, we initiated the system of getting accurate standard thermometers, and verifying thermometers in the late Kew observatory. The Kew committee in connexion with the British Association did a great deal of valuable work in keeping standard meteorological instruments, and in verifying the instruments made by opticians. I believe that 20 years ago it was quite impossible to get a thermometer of any accuracy from any optician, but at present it is to be got with the greatest ease, and that was brought about by the Kew observatory working under the British Association; but the British Association has now given up their connexion with that observatory. If there is a physical observatory, I think it ought to have some duties attached to it connected with the standards of weight and measure.

11,503. In speaking of a ministry for scientific affairs, do you mean that there should be a special minister for science, or that science should form a department of an existing Secretary of State?—I have not studied that question in this particular aspect, and I am not prepared to say which of the two would be the best arrangement. I should imagine that to begin with science would not, perhaps, be enough for an entirely new minister of state; but one does not know what it may come to afterwards, if it be once commenced.

11,504. But at any rate you would, perhaps, think it desirable that there should be a permanent under-secretary under the control of some responsible minister?—Yes.

11,505. And, perhaps, you would prefer that in the present circumstances to a special minister?—Yes, I think I should; it might form a division, perhaps, of the ministry of education.

11,506. (*Chairman.*) Do you think that all questions connected with science should come before that department; for instance, in matters specially connected with the Admiralty, would you have the Admiralty refer scientific questions to this department of the Government?—I should think they ought; and I suppose that the Admiralty would be represented in a council of this kind.

11,507. (*Professor Stokes.*) The question whether there should be a body of scientific advisers to the Government, and the question whether there should be Government laboratories, are distinct, are they not?—Certainly.

11,508. Supposing that it were not decided that there should be Government laboratories, but that it were decided that there should be a body of scientific advisers, ought they, in that case, do you think, to be paid or unpaid?—I think that all advisers giving responsible advice to the Government on questions of that kind should be paid advisers.

11,509. Do you think that they ought to be paid by something in the nature of a retaining fee, or paid as if their whole time were to be occupied?—That depends upon circumstances. If their whole time were not occupied, I suppose they would be paid something in the nature of a retaining fee; that is a point, however, upon which I have not thought very much.

11,510. You have not considered, I presume, from what you say, how such partial services to the Government, that is to say, services occupying only a part of the time of the advisers, could be rendered compatible with other work independent of the Government, such, for example, as giving lectures in definite terms?—No, I have not considered that subject; but still the Government very often call to their aid a council of officers, who are, in one sense, Government officers, and, in another sense, have a good deal of private work of their own, and in those cases the private work has not been found to be incompatible with the Government work. The Attorney General and the Solicitor General, for instance, are the law advisers of the Crown; but they can take private cases as well as Government cases, and they devote a part of their time to the one and a part to the other. It is a question of expense. If the Government wish to secure a scientific man to themselves, they must pay him a good salary; but if only his occasional services were required, I suppose that the Government would make arrangements with him to give only a part of his time to their objects.

11,511. Would you prefer giving him some moderate salary by way of a retaining fee, or paying a fee according to the amount of time which any particular question would require from him to answer, something in the nature of a barrister's fee?—I think that a certain fee should be given proportioned to the time occupied by the adviser in elaborating his advice. I suppose that what guides the Government in the case of the law officers, would be sufficient to guide them with reference to officers whose advice might be required in other departments as well.

11,512. (*Mr. Samuelson.*) Is there any reason to suppose that the advice which the Government would receive from a council would be better than the advice which it would obtain from individuals of high capacity; would it not, perhaps, rather be one of those cases in which, in the multiplicity of counsellors, there might not be wisdom?—It might be so, but you want a permanent arrangement; and then, even if there were a scientific council recognised by the Government, and giving the Government the bulk of the advice that they got upon these questions, still science is so subdivided that it might ultimately be necessary to send for the advice of some outsider, and I suppose, in that case, if advice were required, he would be paid according to some proper method of payment for the advice that he gave.

11,513. Assuming the best man in each department to be on the council, would it, or would it not be better that the advice should come to the Government from the individual member, rather than, if I may use the expression, diluted through the council?—I suppose many such questions would originate with the council, who would represent the Government as far as science was concerned, and would start questions, and if they could not answer these questions themselves, then the questions might be put to some outside body. Then, when a question was started by the Government with regard to science, it might, to a certain extent, be supposed to be started by the council; it would not be started by some member of the Government apart from the council, and put to the council, *B. Stewart, Esq., LL.D. F.R.S.*

31 May 1872.

but very often the question would be started in the council itself.

11,514. But many of those questions, I presume, would come from outside and would be pressed upon the Government, and the Government would refer them to one of two authorities, either to a council or to an individual; which of the two do you think would be the best?—I think that if a council of this kind were recognised, the Government ought to refer them to this council, because they would be considered as the responsible advisers of the Government with regard to a great amount of scientific questions. No doubt there are other questions partly scientific and partly not. You will always find a border region of questions of the kind upon which you are not, perhaps, able to legislate at once; but all truly scientific questions ought to be referred by the Government to the scientific council, who are the authorised and permanently responsible advisers of the Government in all strictly scientific matters.

11,515. In what way would the advice of the council be better than that of the individual members of that council, who are the highest authorities on the question under review?—Because I think that science has a number of bearings, and that a question might involve, not one branch of science, but a great many, and you might, for instance, have to call in various men of science of different kinds. In order to answer this question, you might have to call in, not the advice of one member of the council, but the advice of a number. Of course there are a number of questions regarding which some of the members of the council would naturally be silent, but, perhaps, a good many of them might be interested in answering a particular question and would give their answer. In a case of that kind I should fancy, however, that it ought to come as from the whole body, because, really, in most questions now-a-days, the question would not involve one particular branch of science only, but it would involve the joint operation of two or three branches of science.

11,516. Take, for instance, such a question as that which has been recently referred to a committee, the efficiency and stability of ships of war, would there be any advantage in referring a question of that kind to the council, rather than to a committee specially appointed, as has been done on the occasion to which I refer?—I think that if there were a council of this kind, the council would have power to associate other people with them in a case of that kind. Science is so ramified, that the council would not be able of themselves to settle all questions; but upon particular questions, such as you name, very likely they would associate other people with them.

11,517. Do you think that they would be more likely to make a judicious selection of the persons to be consulted than the Minister of State would be, without the advice of such a council?—I think so, because a minister of state is not likely to know the capabilities of various men. There are a number of men known to scientific bodies as profoundly conversant with particular branches of science, but their knowledge of those subjects does not appeal to outsiders, it only appeals to those who are cognisant with that particular subject. I should say that one of the most important duties of a council of this kind would be to know what individuals would be likely to be authorities on particular points, and to associate those individuals with themselves, when such points come up. At the present moment, really, no scientific advice can often be asked by the Government, because they have not the machinery for getting it. They have no means by which they can obtain scientific advice on a great number of points. They have no one who could tell them who is the proper person to consult, and, consequently, there are a number of things in which science might be very well called in, but it is not called in, or incompetent persons give their opinions, simply because there is no machinery for obtaining scientific advice.

11,518. Who would be the best man to advise the Minister, in the first constitution of such a council?—I think this Commission should advise them.

11,519. (*Sir J. P. Kay-Shuttleworth.*) Have you ever thought whether a smaller body of men, of the most eminent scientific qualifications, might not prove a more efficient consultative body for the purpose of selecting scientific men for special investigations than a much larger body?—With regard to the size of the body I am not prepared to say. I should fancy that, in some respects, the consultative body ought not to be too large; but I suppose that if you had a body of this kind, and at the same time you had a number of institutions—although, as Professor Stokes remarked, those two points are different—yet it might naturally follow that the directors of those various institutions might be members of the council, and, perhaps, you would have a few outsiders at the same time, but not too many.

11,520. (*Chairman.*) You have not, I think, expressed any opinion of your own as to how large the proposed council should be?—No, I have not; but I do not think that it ought to be too large.

11,521. I think Colonel Strange recommended from 30 to 50?—Fifty is a large number.

11,522. Do you think that a council not exceeding, say 10, would be sufficient for the purpose?—I am not sure that I have studied the subject sufficiently to be able to say what ought to be the size of such a council, but 10 might be somewhat too small, and I should say that 50 would be too large. I think, to some extent, an arrangement of this kind must be left to develop itself, like other things.

11,523. (*Chairman.*) In one part of your evidence you recommend that the Government should endow professorships in provincial colleges. Do you think it desirable that the Government should endow special professorships, or, rather, render aid generally to such institutions?—I think the two questions are somewhat distinct. As far as the question of science is concerned, perhaps special professorships are particularly called upon to be the representatives of science; and, as far as the advancement of science is concerned, the aid of Government might, from that reason, if it were not associated with any other, be given to certain professors in contradistinction to certain other professors; but still, as a matter of policy, it would be desirable to endow, to some extent, all the higher branches of learning in the different provincial centres, without making a somewhat invidious distinction between the arts and the sciences.

11,524. Are there any other points which you think require additional elucidation?—I think not. I have sufficiently pointed out the fact that all such observations, at the present moment, are really stopped, and also of what importance it is, if we wish to have an exact record of the sun, that we should have the means of tracing every group of spots across the sun's surface from one part of the limb to the other, and that in order to do this perhaps more than one station would be necessary, so that if there were bad weather at one station we might expect it to be good weather at another; and also that the observations of the sun ought not to be entirely confined to photographic observations at a particular spot, but at the same time we ought to have spectroscopic observations of the sun and observations of the actinic influence of the sun and eye observations. All those observations ought to be taken at the same time. I think we have only to look at what has been done to see under what great disadvantages certain observations of the sun have been taken. We have only to look at the disadvantages under which the spectroscopic observations of the sun have been taken by Mr. Lockyer in this country, to see of what importance it is to have some method of putting these observations upon a better footing.

11,525. Do you consider Kew to be a suitable place for those observations?—I think it is one of the most suitable in this country, and if they had a central station, no doubt, as far as Kew is concerned, Kew would be a good station. But I should fancy that i

B. Stewart, Esq., LL.D., F.R.S.

31 May 1872.

would be desirable to have associated with a central station some other stations, not necessarily in this country, but, possibly, in one or more of our colonies, in which you could be sure, in one way or other, of being able to ascertain the behaviour of each group of spots as it crossed the sun's surface from day to day. About one half of the groups of spots taken at Kew have been lost on account of bad weather. We cannot tell the behaviour of each group of spots as it passes across the sun's surface. We have lost fully one half of the information which nature was willing to give us, by means of bad weather at Kew. There is only a limited amount of spots produced on the sun's surface, and if we do not use our opportunities in getting them, we shall not get more. We have passed the maximum and are going into the minimum years, and in a few years we shall have none at all.

11,526. Would it be inconvenient to conduct those observations at an ordinary astronomical observatory?—Yes, I think it would, because, first of all, they embrace a subject of their own, and next because, in order to be properly carried out, especially the spectroscopic part of the observations, they require to have associated with them something in the shape of a chemical laboratory. In fact, the process is so very different from that of ordinary astronomy, that I should hardly imagine that they could be attached to an astronomical observatory. I believe the present Astronomer Royal, Mr. Airy, when asked to make certain observations that are more immediately connected with astronomy, has replied that he cannot undertake them because they would interfere with his great office of making Greenwich the national timekeeper. He must keep to a certain particular style even of ordinary astronomical observation, and he cannot much depart from it. I should, therefore, imagine that if a large department of this kind were commenced it would be very unfair to the Astronomer Royal to put so much additional work upon his shoulders, and to ask him to undertake the charge of something that was so very different in all respects from his ordinary work.

1,527. Do those remarks apply also to the colonial observatories or the observatories in India; do you think that they have already quite enough to do?—I fancy they do. The most natural adjunct to an observatory making sun observations would be to couple with it meteorological observations, because they, in their present state, require photography, just as the other observations do, and the two seem to be allied together in other respects. I should fancy, consequently, that meteorological and magnetical observations ought to go along with observations of the sun, rather than strictly astronomical observations.

11,528. (*Mr. Samuelson.*) Do you know what the practice is in foreign countries?—In Wilna, in Russia, they make a specialty of sun observations, but I am not sure what other observations are taken there; again, sun observations are not taken in the Pulkowa observatory, which is the great national observatory. Again, in America the observatory which they propose to put under the superintendence of Mr. Young is quite a distinct observatory for the purpose of the sun, and I imagine that it is the same in France.

11,529. In Rome is it the same?—In Rome I do not know what its particular speciality is. Father Secchi undertakes astronomy, spectroscopy, and a great many different things.

11,530. (*Chairman.*) Would observatories of this kind be costly establishments?—I think not.

11,531. Neither in their original construction nor in their maintenance?—No, I do not think that they would be costly.

11,532. What part of the world do you consider the most suitable for the purpose?—I suppose that the great object would be to have two observatories, at any rate, one, perhaps, where the climate all the year may be supposed to be fine, except some particular portions of it, and one at some other place where we may expect that that particular portion of the year which was bad in the first observatory would be good in the second. If an arrangement of that kind were made, if we could take advantage of different climates, I should fancy that it would be the best arrangement.

11,533. You think that if two good places could be suggested that would answer your object?—Yes, I think so.

11,534. (*Mr. Samuelson.*) Speaking of our own stations, do you think that Malta or Gibraltar would be good stations?—I should fancy that there is too much west wind there, and that India would be a better place, and the Cape, perhaps, but I am not sufficiently acquainted with that point.

The witness withdrew.

Adjourned to Wednesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 5th June 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., LL.D., F.R.S.

RICHARD OWEN, ESQ., M.D., F.R.S., further examined.

R. Owen, Esq., F.R.S.

5 June 1872.

11,535. (*Chairman.*) The advancement of science is a subject to which, I may presume, your attention has been directed?—It has.

11,536. Have you any recommendations to offer, the adoption of which would, in your opinion, tend to promote the progress of science in this country?—I have a few, which will be illustrated by the comments which I have noted down in studying the evidence which has been kindly sent to me.

11,537. Do you mean with reference to the statements which have been drawn up by Colonel Strange and by Professor Balfour Stewart?—Yes. I find in perusing Colonel Strange's *précis*, in page 6, that he says, with respect to natural history, "More public "money is spent in England in certain departments "of natural history than in all other branches of "science put together." Upon that I think it right to remark that the impression likely to be received from that statement is, that the amount of public money so spent is considerable, not to say excessive; and it might even be deemed to be such as to be one of the elements that have obstructed the application of public money to other scientific materials or means. I, therefore, thought it would be desirable to furnish the Commission with the amount of public money which was voted last year for the Department of Natural History in reference to the purchase of specimens for the British Museum. For the Department

R. Owen, Esq., F.R.S,

5 June 1872.

of Zoology, the sum voted was 1,000*l*., of Geology 800*l*., of Mineralogy 1,000*l*., and of Botany 250*l*. The total voted and expended last year for objects of Natural History was, therefore, 3,050*l*. The sum asked for in the present financial year is less than that by nearly 300*l*., and I think the Commission may take this total as a very fair average of what we have asked for and received from the State for the objects of Natural History in the last 10 years, or, indeed, since the period of my superintendence of that part of the British Museum. With regard to the statement that "more public money is spent in England in "certain departments of Natural History than in all "other branches of science put together," I would first remark that history is a science, and it is so acknowledged by the State, which provides buildings, galleries, and other conveniences for the arrangement and due preservation of the materials which relate to the advance of the science of Human History, in the same way as our specimens relate to Natural History. Those materials, I need scarcely say, are coins, medals, the evidences of the rise, progress, and application of the artistic instinct in man, the examples of his faculty in making implements and weapons from the flint, to the bone, the bronze, and the steel implement. Add to these the material illustrations of the religious instinct. The sum of all this is, that in the British Museum alone there are four departments relating to the materials that are essential to the advancement of the science of History. There is the department of Egyptian and Assyrian antiquities, the department of Greek and Roman antiquities, the department of Mediæval antiquities and ethnography, and the department of coins and medals. I have not had time to get the precise returns in reference to these materials for science which I have got for Natural History, but I am sure that I am within the mark in saying that the State provides, at least, twice the sum for the purchase of those scientific materials that it does for the Natural History, and I think that I should not be exaggerating in saying that five times as much is expended in that way. I need only remind the Commission of the grant which Mr. Disraeli asked for and obtained from the House of Commons, a few years ago, for one single group of specimens that came under the category of materials for advancing the science of history. It, therefore, appeared to me that there was an indication in this sentence of Colonel Strange's which would lead one to weigh his statements with care, not to say criticism. The next passage is, "I am told by those conversant "with it that our national collections at the British "Museum would be greatly enhanced in value if "means existed for giving instruction regarding "them, and for enabling investigators to study them," and so on (p. 6). First, with reference to the British Museum, and especially its Natural History Department, there are means for giving instruction, which I need not repeat, as I gave evidence as to what I deemed to be the best application of the collections of Natural History in that relation on a former occasion. I will only now take the opportunity of explaining what I did not think it requisite to do then. Having suggested the number of elementary lectures to be given by the keeper or sub-keeper of each department or sub-department of Natural History, and having limited that duty to 24 lectures of an hour each, which of course amounts to one day in the whole year, a question was put to me by a member of the Commission, whether I thought that 24 lectures were sufficient for giving elementary information; it was obvious that my statement was that each keeper or assistant keeper should give 24 lectures, and I specified the departments; so that the course of lectures which I proposed to recommend should be given at the new Museum of Natural History, when it is established, would amount in the course of the year to not fewer than 288. The difference between that course and an extended course of Natural History given by the same individual, say a Professor of Natural History, in a university, or other place of instruction, is this, that each of those courses of 24 lectures will be given by the gentleman who is the expert in that particular branch, and who is most likely to convey the best elementary information and the best information of every kind upon it. I will just run over the heads of them. They are—on the general principles of Natural History, 12—on Mammalogy, 24; on Ornithology, 24; on Reptilia and Fishes, 24; on Mollusca, including shells, 24; on Entomology and its economical applications, 24; on the other Articulate Classes, 24; on Radiata, 24; on Vertebrate Palæontology, 24; on Invertebrate Palæontology, 24; on Botany, 24; and on Mineralogy, 24. They are concurrent with the several departments and sub-departments; and, in view of the present demand for school teachers to convey the elements of Natural History over the whole length and breadth of the United Kingdom, in connexion with the means for public education which are now in progress, I cannot conceive that a national collection of Natural History supported by the State can do a greater service or associate itself more effectively with this great movement than by that little accessory duty being added to the conservative work of the able gentlemen who have the charge of the several departments.

Then Colonel Strange recommends that there should be appropriate rooms and instruments for research, accessible to men of science, duly accredited, in the same way that the library is rendered available, by means of the reading room, to men of letters. Upon that I should wish to observe that, even in our present restricted place, we have rooms for that purpose, to which students can go without being interfered with or stared at by the general visitors to the museum, and that in those rooms there are such instruments of research as microscopes, &c., and also there is a chemical laboratory. That chemical laboratory at present is at a little distance from the British Museum; the Trustees have hired a house for that purpose, but in our new Museum space is provided for it; and not only that, but there will be a very great increase of space for those private studies in which, by means of instruments and other advantages, the scientific visitor can transact his work satisfactorily to himself, and I think in the best way. I have noted the ample provision to this end in the "plans" of the new Museum, which have been accepted by the Government, the construction of which is now being contracted for. A chemical laboratory will then form part of the museum, and in that I quite concur with Colonel Strange. Then, in page 7, he says, quoting from Dr. Michael Foster, "A much more useful way "appears to lie in the establishment at some already "existing institution, such as at Kew or at Jermyn "Street or elsewhere, of a physiological laboratory "furnished with costly appliances," and so on. To this I felt an objection with regard to the specification of of those two establishments, in the fact of there already being in existence and in work, older establishments, more or less formed by and supported by the State, which might have an equal claim to be the locality of such physiological laboratory; and, to be an effective laboratory, no doubt, as my friend Professor Sharpey knows, it must needs be now a costly one. If the Commission should ask what other institutions I would suggest, supposing the State should be disposed to give science that great help, I would name, for animal physiology, the Royal College of Surgeons in preference to any other public institution. It is in fact the national museum of physiology, containing, as we all know, Hunter's physiology as the groundwork, and this has been very ably developed and added to since his time. I quite concur in the locality at Kew for a physiological establishment in reference to plants. That is the appropriate place for observations and experiments on living plants; as, with regard to planting, to nutrition, to the acclimatizing of exotics, and those more subtle physiological experiments of hybridizing, and multiplying sports and varieties; in fact for the carrying on of such physiological experiments as those which have enabled Mr. Darwin, by means of a comparatively small private garden, to contribute informa-

R. Owen, Esq., F.R.S.

5 June 1872.

tion so extremely valuable and appropriate to the present phase of botanical and, I may add, biological science.

My next observations will be almost limited to the main recommendations in Colonel Strange's *précis*. At page 11 his first recommendation is that of a "Minister for Science." I conceive that the recommendation by Bentham, in the last century, of such a minister can hardly fail to be practically adopted before the close of the present century, and that the necessity of having a minister for such a purpose will be recognised. Of course with a minister to represent science before the legislature, and who probably might, being a minister under those circumstances, move with the administration, there must be a Permanent Under-Secretary and administrative Staff. In that I completely concur; but, with regard to the Consultative Council, several objections occurred to me in considering that matter. The consultative council would, no doubt, be formed with the full concurrence, and in complete harmony with the views, of the permanent Under-Secretary. You may take it either way; a consultative council, if it were established, would hardly get on with its work, unless it found a permanent officer in harmony with its views. Assuming the permanent Under-Secretary with a consultative council established, what would be the probability of the Minister going beyond such machinery in reference to any information or advice which he might require with regard to any movement or change in reference to science? I doubt very much whether he would go outside or beyond that body for advice and information. And what do you find? You find, for example, in reference to my own especial science, one Naturalist on the recommended Council. Now there are, and I suppose there always will be, three or more naturalists who might each severally think that they were entitled to a seat and a word on that Council. You would find two naturalists, at least, who are respectively at the head of some public Natural History establishment; one might have a bias toward zoology, another toward botany, a third, perhaps, toward geology. Supposing a question were to come before the Science Minister with regard to the assignment of Government collections of Natural History made in Government voyages, where would the determination be? In all probability with that naturalist who was a member of the consultative council, and such position would give him, in my humble opinion, an undue advantage. There are other questions of that kind that relate to a condition which I desire on the present occasion more particularly to bring before the Commission as an unquestionable evil connected with our present scientific anarchy, and which this Commission, in my humble opinion, will certainly do good to science if it puts an end to, or assists in putting an end to; and that is the existence of rival or competing establishments, each having more or less the character of the leading State or metropolitan establishment, whether for the Natural History of animals or the Natural History of plants. But let me illustrate what has occurred to me with reference to the first, which is a minor, consideration, namely, the disposition by the Government of those collections which are made in circumnavigatory and other voyages at the expense of the State. I will do so by a letter which I found it my duty to address to the Secretary of the Admiralty two years ago, dated the 20th of October 1870, and, with your Grace's permission, I will read this letter. "To the Secretary of the Admiralty. Sir,—In all the expeditions in which the Lords of the Admiralty have been pleased to make provision by adding a naturalist collector, or by selecting a surgeon with special scientific qualifications for the advancement of Natural History, that end has been attained by their Lordships requiring that the specimens collected and brought home should be placed in 'public museums of Natural History for determination and description,' a labour usually undertaken promptly and gladly by the officers or professors of such establishments. Agreeably with this arrangement, the fossil remains from South America collected, during the voyage of the 'Beagle,' by Mr. Darwin, were so placed, and it became my duty to describe them (as in the Vol., 4to., 1836, 'Fossil Mammalia of the Voyage of the Beagle'). The zoological specimens collected in Sir James Ross's voyages, and sent to the British Museum, have been similarly made subservient to science by the labours of my colleague, Dr. Gray, F.R.S., and I might cite many other instances in which, the wise rule of the Admiralty being obeyed, the design of my Lords has been carried out. I regret to have to state that the fossils and other objects of Natural History collected by Robert Cunningham, M.D., naturalist collector of the Magelhan Straits' Expedition, in Her Majesty's ship 'Nassau,' have not been sent to the British Museum, or to the 'Museum of the Royal College of Surgeons,' nor do I find them in the 'Museum of Practical Geology, in Jermyn Street,' where, indeed, they would be out of place, that museum being exclusively for British specimens, and mainly in illustration of the Government Geological Survey of Great Britain. The result is that no account of the fossils collected by Dr. Cunningham, R.N., in the Magelhan Straits' Expedition has appeared."—(Since this was written there is a short note in a work which he has published, which alludes to one of those fossils being, in all probability, an *Anoplotherium*.)—"I cannot help stating that I think myself aggrieved by having been prevented, by the withholding of the fossils from the British Museum, from further advancing the knowledge of the extinct animals of South America, commenced by my labours on the collection brought home in Her Majesty's ship 'Beagle.' These, with contributions to the zoology and palæontology of other voyages, testify to both my desire and power to carry out the views of their Lordships, and I may be allowed to remark that, having been honoured by the duty of preparing the 'Instructions for collecting Zoological and Geological Specimens,' in the 'Admiralty Manual of Scientific Inquiry,' now under preparation for a fourth edition, I feel both surprise and regret in being compelled, in the interests of the public collections of Natural History, at the British Museum, under my superintendence, and in those of science, to bring the fact of the withholding the fossils referred to from the British Museum, to the knowledge of the Lords of the Admiralty." Here is one of the questions that might come before the Minister of Science, and be referred by him to the consultative committee, and what might be the judgment of the one naturalist on that subject?

Then, the next and the main point is the evil to Natural History, both Zoology and Botany, in the continued existence of rival or competing museums. But that is a point which somewhat affects my estimate of the sums expended and granted by the State each year for the purchase of natural history specimens; for you must get the sums of public money expended, say, by the Museum in Jermyn Street, in competition with the British Museum, bidding also with the public money for fossils, which are equally desired by the directors of both museums. You must, in like manner, add the sums of public money spent in the same way for the herbaria, or the collections of dried plants, which have comparatively recently been added to the collection of live plants at Kew; the Director there bidding against the Keeper of the botanical department of the British Museum for such dead plants; each contending by means of grants of public money. And I think this so important a matter for the consideration of the Commission, that I would ask permission to read what I have put down as bearing upon the competing museums of Botany; the botanical department, for example, under the Board of Works, and the botanical department under the Trustees of the British Museum. It is rather a long statement, but it may contribute to put the Commission in possession of some

R. Owen, Esq., F.R.S.

5 June 1872.

of the circumstances which have to be considered in this matter.

The British Museum, the Zoological Gardens, and the Royal Gardens at Kew subserve, in different degrees, the instructive recreation of the public, and the advancement of science. The contrast in this respect, or diversity of application, agreeably with the original design and will of the State, is greatest between the botanical department under the Trustees of the British Museum and the botanical department under the Board of Works. The first, founded and supported by the State, primarily, for the advancement of botanical science, fulfils in but a small degree, from its very nature as a herbarium or museum of dead plants, the recreation of the public. The Royal Gardens at Kew not only minister in a great degree to the recreation of the public, but afford the means of adding to the wealth and enjoyment of the people by scientific treatment of living plants. The menagerie in the Regent's Park has relations to the animal kingdom like those of the gardens at Kew to the vegetable kingdom; its chief application is in the instructive pleasure of the public; its scientific one was designed, mainly, to be in economical relations. But, as it is not supported by the public purse, the management avails itself of the zoological collections of dead animals and parts of such, and of the library, in the British Museum "for naming the animals in the menagerie, and "for giving to zoologists and zoological travellers "the information they require." The necessity for a herbarium or museum of dead plants and parts is the same for the determination of new species of living plants received into the botanical gardens, as is the necessity of a museum of preserved and prepared animals and parts of animals for the determination of new species of living animals received into the Zoological Gardens. But the necessity of such museums being part of such establishments is very far from obvious; it is in the degree of the contiguity of Kew and of the Regent's Park to the British Museum, where the nation had provided, prior to the establishment of both the Botanical and Zoological Gardens, the means of determining their living plants and living animals. In the time of the Aitons, father and son, the distance between Kew and London, reckoned by the time and facility of traversing it, was much greater than it now is; yet the botanical department of the British Museum, with its scientific officers, sufficed for all the work of determination of the new and rare specimens received during the directorship or curatorship of those estimable and practical horticulturalists.

The "*Hortus Kewensis*" of the Aitons, was, at the date of publication and long after, one of the standard works on botany, and the scientific determinations therein, for which Dr. Joseph D. Hooker affirms the obvious necessity of a second or duplicate National Herbarium at Kew, were done by Dryander, Solander, and Robert Brown, the librarians and curators of the Banksian and National Herbaria now in the British Museum. Such work would be equally well done by the present profound botanist, the successor of Robert Brown. The delusion that a museum of Natural History must be essential, as juxtaposed, to a garden or a menagerie, swayed for a time the direction of the London Zoological Gardens; but these, not being maintained by the public purse, but by the subscriptions of private individuals, the real state of the case was sifted and the delusion recognised. The Museum of Zoology was abolished, its contents distributed to the proper establishments where they were wanted and were truly useful, namely, the anatomical specimens to the Royal College of Surgeons, and the rest to the Zoological Department of the British Museum. The scientific applications and publications of the Zoological Society have in no degree deteriorated or diminished since the determinations and comparisons of their new species have been carried out by means of the national establishments founded and supported by such work. Thus, not only is the necessity of a perfect and complete herbarium at Kew not "obvious," but the contrary. How far such alleged necessity has been "universally recognised," may be judged by the "Notes on Mr. Russell's Memoranda," by John Joseph Bennett, Esq., F.R.S., keeper of the botanical department (sent into the Trustees January the 15th, 1869, and forwarded by them to the Office of Works), and by the evidence of his experienced successor, William Carruthers, Esq., F.R.S., before the present Scientific Commission.

A botanical museum, including a herbarium for the advance of the science through the naming of existing species and the determination of extinct species of plants, fulfils the aims for which the nation provides and supports it, in the degree of the completeness of its collections. In the measure in which a competing museum and herbarium, also maintained at the public cost, approaches, through the interception of State collections of Botany and by out-bidding at botanical sales, to the completeness affirmed to be a necessity at Kew, it detracts from the utility and primal aim of the older metropolitan national museum. Colonel Strange has well recognized (p. 9) the value and importance of aiming at "completeness" in a State scientific institution.

To give an example of the evil of maintaining two such State institutions, nullifying completeness by rivalry:—The Herbaria collected by Banks and Solander in the circumnavigatory voyages of Cook, and those collected in the later voyage of Flinders, were deposited, with the sanction of the Admiralty, in the Botanical Department of the British Museum. By and through these herbaria, with the aid of the Banksian Library, subsequently bequeathed with his remaining natural history collections by Sir Joseph Banks to the British Museum, Robert Brown was enabled to produce his works on the botany of Australasia, raising the science of plants in a degree second only, if inferior at all, to that effected by the immortal works of Linnæus. On every account, scientific, administrative, and economical, collections of dried botany subsequently made by Government officers in Government expeditions, especially those supplementing the illustrations of Australian and New Zealand vegetation, previously arranged for the service of science in the British Museum, ought to have been located there. But the portion of the botanical collections made during the Antarctic Expedition by Sir James C. Ross which has found its way to the British Museum is the Cryptogamic, or that including the Mosses, Fungi and Lichens. For the higher organised or phanerogamic part, by far the larger proportion of the collections, the botanist requiring a comparison of them with the earlier described species from New Zealand and Australia is now compelled to go from the Botanical Department of the British Museum, to the competing department developed by Dr. Hooker at Kew. Not only so, but since the Antarctic Expedition of Sir J. C. Ross the Royal Gardens at Kew, according to the present Director's evidence, have been the recipient of almost all the collections made by Government expeditions; that is to say, not merely the specimens of living plants, which would have found there the appropriate location, but the dried and other prepared specimens of dead plants (herbaria), which have been thus diverted from the metropolitan museum.

The main end or drift of Dr. Hooker's evidence before the Scientific Commissioners is to impress upon them the necessity of the transfer of the collections of dead plants (the palæontological part or the fossils excepted) in the Botanical Department under the Trustees of the British Museum to the Botanical Department under the Board of Works; in other words, the abolition of the Botanical Department in the British Museum and its reduction to an appendage to the department of palæontology. Also, that the botanical department to be transferred from London to Kew should be under one head; that is to say, the Director of the Botanical Department under the Board of Works. The evil here threatened, in my judgment, to science, to the integrity of the National Museum of Natural History, and to its extended uses in aid of national

R. Owen, Esq., F.R.S.

5 June 1872.

education, compels me to submit to the Scientific Commission evidence of what appears to me to be the depressing influence of the herbarian work done at Kew upon the physiological work originally contemplated to be carried on there as a collection of living plants.

The scientific work of which a herbarium is the instrument has been defined by a great wit and original thinker as the "attaching barbarous binomials to dried foreign weeds." This roughly expresses the net result of the application of a museum of dried plants. It is the proper and authoritatively assigned labour of the keeper of the Botanical Department under the Trustees of the British Museum. But a great naturalist has given a better and more appropriate opinion upon that subject. I allude to Gilbert White, of Selborne, who remarks, "The objection to herbarian " botany is that it exercises the memory without im- " proving the mind or advancing any real knowledge; " and where the science is carried no farther than a " mere systematic naming and classification, the " charge is too true. But the botanist who is desirous " of wiping off this aspersion should be by no means " content with a list of names, he should study " plants philosophically, should investigate the laws " of vegetation, should examine the powers and " virtues of efficacious herbs, should promote their " cultivation, and graft the gardener, the planter, and " the husbandman upon the physiologist."

To raise the weed to the condition of a plant useful to man's estate is the work of a Director of a national collection of living plants in adequate gardens and buildings, with all appliances for culture and required experiments, liberally provided by the State to that end. Most of the plants now of greatest use to man were originally weeds. I might cite the wheat, *Triticum vulgare;* barley, *Ægilops ovata* [?]; rice, *Oryza sativa;* rye, *Secale cornutum;* potato, *Solanum tuberosum;* yams, *Dioscorea sativa, Dioscorea alata,* and *Dioscorea globosa;* the artichoke, *Helianthus tuberosus,* and so on through a long list. Almost yearly are additions made to the list of these inestimable developments and conversions. I am not cognizant of any evidence of such (as new flowers or fruit) having been, since the establishment of the herbarium, raised and developed at Kew. The Horticultural Society, originated and supported by voluntary contributions, supplies, in its degree, the absence of the practical applications to that economical end in the Royal Gardens. Yet this surely is the true and legitimate scientific work of the Director and his appropriate staff. The results of competitive exhibitions of new and valuable kinds of fruit, grain, grasses, succulent and other vegetables, flowers and other plants of ornament, are the results of applied physiology, and the prizes are the due reward of science and skill in this department of botany. Although no new variety of fruit or flower appears, in the last issued "Report," to have been developed at Kew, the Director therein states that, "during the " past year, about 10,000 specimens have been added " to the herbarium."

By the foregoing remarks upon this instance of competing public museums, each supported and claiming to be supported by public money, I trust that I may have given to this Commission some grounds for considering how far they will lend their great influence to the abolition of that unquestionable detriment to science. And with regard to the more direct means for advancing science, I strongly urge that the idea of a consultative council in which the different sciences appear from their very extent to be limited to one cultivator of each, should not be entertained. It appears to me that it would be much better to leave to the Minister of Science, if ultimately there should be such a Minister, the power to apply for scientific information to whoever he deems best able to give the required information, and to get it from more than one representative of each branch of science. Such appear to me to be the considerations which I thought might profitably be submitted to the Commission in the short time that I have been enabled to study the documents upon which my opinion has been requested.

11,538. You object mainly to a consultative council because you consider that it would tend to encourage this competition of Government institutions?—It would tend to encourage one at the expense of others. For example, supposing that a single naturalist were a member of that council, the question would be whether, in a case of this kind, he would deal quite impartially between Mr. Carruthers and Dr. Hooker, and so with regard to any other analogous case; it is always uncertain how far social relations of friendship, and intimacy, and so on, might not have their effect in such a question.

11,539. You are aware that, although there would only be one naturalist, there would be a large number of other scientific persons on the council, and that his views alone would not necessarily be supreme?—I am afraid that there would not be one of them who would feel himself competent to oppose the opinion of such a naturalist on a purely zoological or botanical question, and you will observe that in this council proposed by Colonel Strange, the naturalist is supposed to be both a zoologist and a botanist. I may say that I fully estimate, as everyone does, the admirable amount of work which Dr. Hooker issues through the instrument of the Herbarium and collection of dried plants. There is only one other remark which I should wish to make, namely, that anything which I have urged with regard to the advantage of making the one public metropolitan museum as complete as it can be made, is not to apply to the secondary and local museums either in the metropolis or in the country. In fact, if to the one State museum in London all the collections from the Government expeditions were sent in the first instance, then would arise the duty which Sir John Lubbock more particularly has urged upon this Commission, of the officers of that public museum, to set apart and arrange the duplicate specimens which might be available for distribution to local and provincial museums.

11,540. (*Professor Stokes.*) In the case of palæontological specimens one can understand that, as the supply is limited, and as it is a chance when we come across a specimen of the finest kind, two competing establishments might act injuriously on one another, but in the collection, say by means of the ships in Her Majesty's navy, of specimens of living plants, would there be any difficulty in collecting specimens enough for two national museums, if for any reason it was thought desirable that there should be two, having different objects in view?—No. With reference to plants, or at least to dried plants, the facilities for collecting botanical specimens illustrative of specific and other characters are generally such that many duplicate specimens might be collected, such as would supply certainly two collections; but with regard to living plants, that would be more difficult. Ward's cases have given great power to their successful importation: but living plants form no part of the Botanical Department in the British Museum, and we should not compete for them.

11,541. (*Chairman.*) With regard to some collections by Dr. Cunningham, do you know what became of them; are they still in existence anywhere?—The only knowledge that I have is a letter which I got from the keeper of the Zoological department under my superintendence. Dr. Gray had given a very good account of the seals and whales in reference to Sir James Ross's Circumnavigating Expedition, and this is the answer which I received from him, when I addressed the heads of all the Natural History departments in reference to this Government collection:—

"British Museum, November 4th, 1870.

"Dear Professor Owen,

"We have not received any specimens of seals " and cetacea from the Magellan Straits' Expedition.

R. Owen, Esq., F.R.S.

5 June 1872.

"I have no absolute authority for the statement, "but I believe that they were sent with other recent "and fossil mammalia to Professor Huxley.

"Yours faithfully
"J. E. GRAY."

If the Commission should deem this correspondence an element with reference to their ultimate conclusions as to a scientific consultative council, that might influence the minister in his decision on such points, I would recommend that the correspondence on this subject with the Secretary of the Admiralty should be transmitted to this Commission. It is about the date of 20th of October 1870, and in it will be found a letter from the late director of the Competitive Museum of Geology, Mineralogy, and Palæontology, supported by the Government in Jermyn Street. Sir Roderick Murchison wrote, in answer to my application, a note which you will find in that correspondence expressing surprise that the fossils had not been sent to the British Museum, stating that they had never been received in his museum in Jermyn Street, that he had never heard of them, and, he added, that if they had been sent by the Admiralty to Jermyn Street he should have immediately transferred them to the British Museum, as not being connected or related in any way to a museum having for its express object, to illustrate the special geology of the United Kingdom.

11,542. (*Sir J. Lubbock.*) Where are those specimens to which you allude?—You are not the only one putting this question. Foreign palæontologists, for it is a matter of extreme interest, have come to the British Museum, and have, also, asked, "Where "are those fossils that have been brought by the "Nassau from the Magellan Straits"? I have been compelled to reply, I have not got them: and you may easily imagine the inference which such foreign palæontologists may draw, viz., that the Government has not sent its fossils to the British Museum, because there they do not know what to do with them or how to make use of them.

11,543. Where are they?—They are in Professor Huxley's private possession at this moment. It was in 1870 or 1869 that they came, and we are now in 1872. No doubt no one is more competent to give an account of them than Professor Huxley; but if they had come to the British Museum, they would have been described and figured in the same year, and publicly displayed for the benefit of all home and foreign palæontologists.

11,544. (*Dr. Sharpey.*) Did you receive any answer from the Admiralty?—I did, and you will find that answer in the correspondence. The answer was to the effect that they took the matter into consideration and distributed those specimens to the public collections which they thought would be best benefited by them. We got a certain share of invertebrata at the British Museum: the birds were sent to Cambridge. We found upon subsequent examination that they were duplicates of our bird-collection, and they are now doing good duty at Cambridge, but in the museum in Jermyn Street, where the Admiralty intended the fossils to go, there are not any of them, and it would not be the proper place for them.

11,545. You have stated the present inconvenience from competition of those collections under existing conditions, and pointed out that it could not be remedied under a Consultative Council; in what way could it be remedied? Have you any suggestion to make of something better than this Consultative Council?—If the old principle were continued that Government collections made in Government voyages and in State vessels were sent to the main prime metropolitan Government museum, there would be no difficulty at all; but the evil arises from the cropping up of competing establishments; for although, in its primary aim, the Jermyn Street collection is intended to show illustrations of the geology of Great Britain, yet it has competed for the acquisition of fossils that should be placed in the British Museum in a way analogous to the competition for dead plants as between the British Museum and Kew. Here is the way in which that acts with regard to collections made with public money. An officer of the establishment at Jermyn Street may represent to the Admiralty that he is a Government officer, and he is an officer in a public or State museum, which may be thus brought into competition with an older State museum.

11,546. With whom should the decision rest, do you think?—There would be no need of this decision if you adopted the really wise administrative principle of having one metropolitan museum for a complete series of all departments of Natural History.

11,547. With reference to a minister of science, would he decide such a question after obtaining information where he thought he could best find it?—Most probably.

11,548. (*Sir J. P. Kay-Shuttleworth.*) You are contemplating, I apprehend, that the one central metropolitan museum should be more or less under the direction of the minister of science?—No doubt of it.

11,549. And, therefore, out of that subordination to the minister of science would flow the subordinate arrangements for distribution to local museums which you contemplate, and not simply their due collection from all departments of public administration, but also the distribution to all classes of public utility?—That is so.

11,550. (*Dr. Sharpey.*) In the case of a consultative council any advice that was given to a minister would probably be in the shape of reports which could be produced to Parliament if required. At present when a member of the Government consults with a man of science as to the advisability of any step to be taken, so far as I know, there is no public report respecting it. Would it not be an improvement if those communications were less of a private character and more publicity were given to them?—No doubt that would be so.

11,551. By your own admission, the present state of things is not what you would approve of, and it would be very desirable for the Commission to have the opinion of a man of your experience and judgment as to how it could best be remedied. You think that it would be not by a consultative council, but by a minister and a permanent secretary who could obtain advice when he thought fit?—Precisely so, *ad hoc.*

11,552. And then that that advice should be reported?—Unquestionably.

11,553. (*Sir J. P. Kay-Shuttleworth.*) The Commission have had before them many other objects for such consultative council besides those which are included in the evidence of Colonel Strange, and it has been suggested to the Commission that it would not be necessary to have so large a council as that which has been contemplated by Colonel Strange, representing every particular department of Science, and not only that, but representing the practical application of science to the wants of the Government and of the community. It has been represented that very eminent scientific men have two distinguishing qualifications, on the one hand, a special aptitude for some particular branch of science, and, on the other hand, a large knowledge of the modes of scientific investigation, and an acquaintance with the eminent men in the scientific world, and of the mode in which science may be applied to the wants of the State and of the community, and, therefore, that a smaller body of very eminent men might be resorted to as a consultative council to the minister, supposing that a Minister of Science were appointed: have you any view as to the comparative utility of such a smaller body, say, of six or eight men?—I think that a body, representing a consultative council, would do its duty much better if selected by the minister of science, or the minister of State for science, for the special question before him, and the report and the evidence so submitted to him might be made public in the way in which Dr. Sharpey suggested, and that there should be no difficulty to find a

R. Owen, Esq., F.R.S.

5 June 1872.

consultative council of the requisite quality and extent for each such special question.

11,554. You are probably aware that the Secretary of State for India is aided by a council which might be regarded as co-relative to the consultative council of the Minister of Science, and that not only no inconvenience has been experienced from its operation, but that considerable advantage has been derived from it by the administration ?—I am aware of that ; but that analogy is wide, and I do not see its application to the very diversified subjects of science. We know the special nature of the Indian work, and the desirability, of course, of having experienced Indian officers in that matter, but I do not think that the analogy of that council would apply to the very diversified subjects of science: and, above all, there is the necessity of not having any predominating voice or influence of any one individual, as representative of a science, likely to affect the minister which, of course, to the degree of the peculiar views and relations of such individual, might affect him unfairly.

11,555. Let me suppose the case that there should not be a naturalist upon the council, which is, of course, an extreme supposition, yet if there were six very eminent scientific men they would know who were the best naturalists in the country to be entrusted with any special investigation, or to give advice upon any special question, whereas it would be very difficult, would it not, in the changing phases of politics in this country, to have a minister or an omniscient secretary who should be equal in his power of selection to a council so constituted ?—I apprehend that the permanent Under-secretary would know perfectly well that part of his duty, and it would be his duty to know who were the experts in the different branches of science to whom to refer. That might not be so with regard to the minister, but the permanent Under-secretary would or should have that knowledge.

11,556. (*Chairman.*) Then you think that the permanent under-secretary would discharge the duties of the council ?—Yes; consulting, when necessary, the experts on a special topic.

11,557. (*Professor Smith.*) You think that with a permanent under-secretary there would be sufficient machinery for obtaining for the benefit of the Government the advice of the most competent and scientific men ?—I believe so.

11,558. (*Professor Stokes.*) Do you imagine that a permanent under-secretary would be prevented by his obligation to be acquainted with men of all branches of science from being influenced by partiality towards anyone ?—Most probably so ; he would be acquainted with the reputations that are fairly and legitimately built up by different men and would consult them impartially. It would not be necessary that he should himself have a profound knowledge of each science, but the general kind of knowledge which is required for the working of a department.

11,559. (*Sir J. P Kay-Shuttleworth.*) In this country there is generally a disposition to avoid dictatorship, and the view of those who have presented this evidence to the Commission has obviously been to have a council representative of scientific men in the country to prevent either the arbitrary conduct of the Secretary of State or of any permanent officer,—do you think that there would be in that view some advantage in a council ?—There would be the power of applying to the councils of the different scientific societies, the council of the Linnæan Society for one, the council of the Geological Society for another, and the council of the Zoological Society for a third class of questions in natural history : to say nothing of the council of the mother of all our learned societies, viz., the Royal Society : in these we have already a guarantee against any dictatorship or arbitrary decision.

11,560. Would you render that obligatory upon the Minister or the permanent Under-secretary ?—Not on every topic.

11,561. If it were not obligatory, would it not come to be discretionary to the extent, in the case of persons of strong will, of being altogether void ?—You then fall back upon public opinion. When a minister who chooses not to avail himself (in a case in which obviously so availing himself would be important) of the opinion of the council of any of the constituted scientific societies, I think that public opinion would prevent any great mischief being done.

11,562. Should we not be in the difficulty of being *coram non judices*, seeing that the public is not a scientific public ?—Perhaps I am being led out of my own depth, not having gone into administrative questions to the extent to which it is well known that you have.

11,563. (*Professor Smith.*) I think you have referred to a chemical laboratory which has been established in connexion with the British Museum ; that is at present a very small one, is it not ?—It is quite sufficient for the very varied and very delicate work which the keeper of the minerals requires ; it is efficient for that purpose.

11,564. But it is not at present in any manner available for the use of students who come to the museum ?—I cannot speak with confidence—but I believe that, if it were requisite for testing or solving any moot point, Professor Maskelyne would give the scientific mineralogist the use of that laboratory. Students have, now, no access to it as a matter of right.

11,565. In the new building at South Kensington, at any rate, the arrangements will be such as to render that possible ?—Yes, space is assigned there in immediate connexion with the mineral department, for all its working requirements ; not only a laboratory, but a goniometrical room, and we have provided for a microscopic room in special relation to the minerals ; everything that is requisite for the scientific application of that and other collections will be provided in the museum which is now, I believe, in course of erection.

11,566. In connexion with this subject, have you formed any opinion with regard to one of Colonel Strange's proposals, that of having a great national chemical laboratory or physical laboratory for the use of scientific men ?—I noted it, but it seemed to bear more particularly upon chemistry and physics ; and I am not able to say much about it. Of course, I have turned over in my own mind the proposition with regard to a physiological laboratory, with its means of experiments in connexion with the pulse and respiration, and other important physiological objects. I think that would be of great importance, and I think it certainly ought to be established, and placed where it could be best used, and that led me to suggest, in the early part of my evidence, that such a laboratory should be in connexion with the National Physiological Museum.

11,567. I understood you that it should be in connexion with the Royal College of Surgeons ?—I mean that body ; the Hunterian Museum there was purchased by Parliament and placed under " inspective " Trustees. There is an Act of Parliament which makes it analogous to the condition under which the British Museum exists ; with this exception, that the Trustees in the latter are " administrative," and that the Physiological Museum is supported by funds which are not directly obtained from the State, but are obtained indirectly by the power which the State gave to the council of the Royal College of Surgeons to demand certain fees in granting their diplomas, and that has enabled them to maintain this National museum.

11,568. (*Dr. Sharpey.*) Supposing a ministry of science, constituted as you propose, would you suggest any change in the government of the British Museum ?—I should decline, as a servant of the Trustees, answering that question. I owe so much to the Trustees, and they are so ready to carry out their officers' suggestions and requirements, that I would rather leave it to administrative experts to speak on that administrative point.

11,569. (*Chairman.*) Are there any directions in which you think it desirable that a larger amount of Government money should be applied towards the promotion of science than is the case at present, and are you able to give any opinion upon that point ?—

R. Owen, Esq., F.R.S.

June 1872.

An increase of grants for conservation and additions will certainly be required when we have effected the transfer of the national Natural History from the British Museum to the museum now in course of erection. The extension of the display of the different departments, and the additions of duties to make those departments more subservient to the work of public education, and the diffusion of knowledge, will be inevitably attended with demands upon the State for a corresponding increase of funds. In fact the ratio in which additions will accrue will be very much increased; but for the last 10 years we have been obliged to be reticent of opportunities from the very physical fact of not having space for such additions as we might obtain. We have been obliged to refuse rather than invite. But, except as regards Natural History, I do not feel competent to state the conditions upon which further demands upon the State might be requisite or imperative.

11,570. Have you formed any opinion as to whether it would be desirable that the Government grant of 1,000*l.* a year, placed at the disposal of the Council of the Royal Society, should be increased or not?—It has been so admirably applied and with such gain to science, that there cannot be a doubt that it would be a great benefit to science if it were doubled to begin with. I have said on a former occasion, when I was President of the British Association, that although it might seem to a statesman to be putting into a lottery to grant this 1,000*l.* for the purpose of aiding abstract scientific research, yet it was a lottery that had been proved to yield many prizes, and those prizes of inestimable value. A statesman might see a man apparently playing with a trough of water, a shelf, and some tumblers, and bubbles of gas going in, and it might seem as though it were an innocent amusement; but out of that a prize has come, namely, the illumination of all our cities with gas, and one of our stipendiary magistrates reported that crime diminished two thirds in the first year that London was lit with gas. And the same with Galileo applying his small tube to spy out bodies rolling round Jupiter. That may have seemed to some of his Italian contemporaries a harmless amusement; but we know that in navigation the results or applications of the discovery have been second only, if second at all, to the invention of the mariner's compass; and so we may go on. The blanks are few, the prizes many; and when a nation gains, through the discoveries of science, a working steam-engine or an electric telegraph, there is no one in the State more benefited than he who, in Carlyle's somewhat irreverent language, "wields the spigot of taxation"—viz., the Chancellor of the Exchequer.

11,571. You think that a considerable increase in that grant would probably produce good fruits?—There is no question about it.

11,572. (*Sir J. P. Kay-Shuttleworth.*) If, instead of being simply doubled, it were increased many-fold, and the arrangements of the administration were such as not to tax voluntary labourers in science, but that there should be an adequate body of administrators, do you not think that a much larger sum might be applied beneficially to science?—Unquestionably; and it would be a very small sum, even when made much larger than it now is, compared with or in relation to the unexampled amount of wealth which is converging to this country, through the applications of inventions, which are the results of inferior modes of thought suggested by—I might say parasitic on—the fruits of those higher gifts whereby are made known the modes of operation of the power of God.

11,573. (*Dr. Sharpey.*) Do you think that while a fixed sum was habitually assigned for distribution by the Royal Society, the Royal Society should be encouraged, when occasion arose, to apply for a larger sum?—I think it would always be able to show good grounds for such application.

11,574. (*Professor Stokes.*) It struck me, as you gave your evidence respecting what you conceive ought to be the duties of the Director of the Kew Gardens, that they were in a great measure those of a florist, and which would be taken up naturally for the sake of gain by florists throughout the country, and agriculturists. Should not the duties of such a director be rather those of a scientific character?—Your question goes to the pith of the matter. The duties referred to are neither appropriate nor congenial to a botanist of the repute of Dr. Hooker. They are among the proper duties of a Director of the Royal Gardens at Kew. The development of a new flower, of a new variety of grape or peach, or any other fruit or vegetable, is a physiological work. It is very true that those who pursue those works, for the most part do it, having an eye to the monetary profit; everything that is improved in this world has its improved price. If a person, or the State, provides a large garden, hot-houses, greenhouses, and every physical appliance which are required for and conduce to the success of such experiments, certainly it seems to me but reasonable to expect that such work should be done. You may use the term "florist," which relates to the lowest result of that work, but let me just mention one of the manifold benefits that might flow from other results. At the present moment, in connexion with the movement for improving the health of towns, the great question is how to turn the excreta of the sewage to advantage. Experiments are wanting on different varieties or species of grass, to show what variety or species feeds best upon the excreta, or makes the best use of the food that it gets. I know that some of the most devoted sanitarians would be glad if experiments of that kind were carried on at a Government establishment, which provided the requisite means for them. Because, if they went to Waterer, or Paul, or Rivers or Jackman, or any of those men whose names are justly famous for the success of their experiments, these being carried on with reference to direct gain, they of course would not see their way to remuneration by so helping the commonwealth. Yet, if you could only show that one kind of grass in addition to Italian rye grass, for example, would feed better than another upon the sewage of towns, and form good food for beasts, you might have a result that would pay a hundred or perhaps a thousandfold the whole cost of the Kew Gardens.

11,575. (*Dr. Sharpey.*) Would not such experiments require a very large extent of ground, and are you aware that experiments in agricultural chemistry have been carried on to a large extent by Mr. Bennet Lawes?—I know those experiments and the geological discovery which initiated them.

11,576. And you are aware, perhaps, that he has made arrangements to endow his establishment with 100,000*l.*, the proceeds of which are to be applied to carrying on, in all time to come, those agricultural experiments at Harpenden, in Hertfordshire?—Yes. But it is a mistake to suppose that you need a great extent of ground for those experiments: you may try them severally, for each subject-vegetable, on a plot of prepared soil hardly more than the extent of this table, and get a result that will indicate what should be done on a larger scale.

11,577. But you require a variety of experiments to be carried on during the same season, and you have only a limited amount of ground. They are not like chemical experiments in a laboratory, which you can repeat any day?—It was pointed out to me by a great English sanitarian—Edwin Chadwick, C.B.,—who had failed in the opportunity of getting the experiments tried in England, that he had to put himself into communication with Moll and other practical botanists in Paris; who, by desire of the late Emperor of the French, applied two or three acres of ground so allotted them for the purpose. This was divided into small compartments, and the sewage was applied in the manner of Charpentier, by subterranean pipes conveying it direct and without evaporation to the roots; they put one kind of grass in one plot, and another in another, and a third kind of vegetable in a third, and so on. These were all

R. Owen, Esq., F.R.S.

5 June 1872.

subjected to the same amount and nature of sewage, and the results were noted: so that you do not require a very great extent of ground. The extent of ground now assigned at Kew for the growth and treatment of living plants is very considerable, indeed quite equal to all the needs of experimental botanical science.

The witness withdrew.

Rear-Admiral GEORGE HENRY RICHARDS, C.B., F.R.S., examined.

Rear-Adm. G. H. Richards, C.B., F.R.S.

11,578. (*Chairman.*) I believe you are the Hydrographer of the Admiralty?—Yes.

11,579. And also a Fellow of the Royal Society?—Yes.

11,580. Have you considered how far it is a proper function of the Government to promote the progress of science?—I think, if not the duty, it is clearly to the advantage of the Government to do so.

11,581. Are there any recommendations which you can offer to the Commission as to the best mode in which the Government can promote the advancement of science, especially with reference to the establishment of a ministry of science aided by a consultative council?—I have seen the proposition of Colonel Strange, and I think there can be no doubt but that if the services of a number of eminent men who represented all branches of science were at the disposal of the Government, it would be of great advantage to the public.

11,582. Have you formed any opinion as to the best mode in which such a council could be constituted?—I think that it would require a large body, and possibly there might be some difficulty as to the practical working of so large a body. Of course, their relation to the Government would have to be very clearly defined, and I think that they should be free from all administrative or executive duties. As regards the Admiralty, perhaps, they are less in want of such scientific advice than any other department of the Government.

11,583. (*Dr. Sharpey.*) Then you would not advise the introduction, as *ex officio* members of that Council, of public servants engaged in the administration of the scientific departments of the Government?—I should not see any objection to such a course, unless it is that the time of the Government servants is entirely occupied; at least such is the case at the Admiralty.

11,584. (*Chairman.*) Do you think that the appointment of a minister of science is desirable?—I think if you had the council it would be desirable that it should be so presided over.

11,585. But you would not recommend the appointment of a minister of science unless he was aided by the advice of a council?—I do not think that the one would be of very much value without the other.

11,586. The constitution of the council, as recommended by Colonel Strange, would be something of this sort,—every branch of science would have a representative, and there would be also certain other elements represented in the council. Do you think that on any particular question of science the advice of such a body would be valuable, although, in all probability, there would be but one or two members specially conversant with that particular department of science?—Yes, I think certainly it would be valuable.

11,587. You think that the opinion of a large body of scientific men, even on questions with which they were not themselves specially conversant, would be valuable?—On very many questions I think it would.

11,588. Do you think that the advice of such a council would be preferable to the advice that could be obtained from special committees appointed to consider special questions?—Yes, I think so. I do not believe that special committees are at all advisable on professional subjects.

11,589. Have you any experience of special committees which has led you to form an unfavourable opinion of them?—I think that the members of such committees must be selected more or less to fulfil certain political conditions, and that, as a rule, they would come new to the subject that they were going to consider, and I do not believe that the Commission which sat on the naval designs the other day was a very successful one. I do not know that any great advantages have arisen or are likely to arise from it.

11,590. You would place greater confidence in the advice of such a consultative council?—Yes, undoubtedly; they would be, to a certain extent, a permanent body and an independent one, chosen entirely for their qualifications as scientific men.

11,591. If such a council were established, would you contemplate that the Admiralty would apply to the minister of science aided by this council on any question of a scientific nature that required consideration?—I think that the Admiralty requires the aid of such a council less, perhaps, than any other department of the Government, for this reason that there are not very many questions, purely questions of science, that come under the notice of the Admiralty; and then we have the Astronomer Royal to refer to, who is a host in himself, and if any question arises which we do not refer to the Astronomer Royal, we generally ask the President and Council of the Royal Society, and we have never found any difficulty in getting assistance. The only department of the Admiralty which might require such assistance beyond this, is, perhaps, the Constructors' Department, in the designs for ships of war. But as regards that, my opinion is, that it would be far better to have some scientific designer attached to that department than it would be to refer such questions to a council even.

11,592. So far as I understand you, you do not consider that the Admiralty, at any rate, would derive any great advantage from the establishment of this proposed council?—There would be this advantage, I think, which they would derive, that they would be freed from the political pressure which is brought frequently to bear upon the Admiralty upon questions of that kind. The whole responsibility of deciding upon a measure would be thrown upon the council.

11,593. Do you think that would be a desirable result?—I think that it would be desirable in all departments of the Government; it would be very agreeable to the Government of any day, I should think, to escape the responsibility of deciding on scientific questions on which they may not be very intimate, but in which they may be believed to be interested parties.

11,594. Do you think that the work would be better done?—I think it would. I should say there could be no doubt about that, but unless the Government are prepared to vote a very considerable sum every year for the advancement of science, which I am quite of opinion that every Government ought to do, I think very little benefit would accrue from having such a council.

11,595. You say that you think that a large sum of money ought annually to be voted for those purposes; can you point out any directions in which you consider this money might advantageously be expended?—Numerous cases will arise. I suppose every one of the council would naturally have some particular branch of science that he would wish to forward, and it would be his duty to do so. For instance, if it were intended to equip an expedition, as we are going to undertake now, for the physical investigation of the ocean, among other subjects, you must bargain on 25,000*l.* a year for it. Then, I suppose, that Sir William Thomson and the Tidal Committee of the British Association would like to establish on the sea shores of the world self-registering tide gauges, and that would be an expensive arrangement if undertaken by any one government. I am of opinion that a very large sum would be required every year, and that it could be profitably spent.

11,596. Do you see your way to the expenditure of

Rear-Adm. G. H. Richards, C.B., F.R.S.

5 June 1872.

a very large annual sum?—There is not the least doubt about it in my opinion.

11,597. And it is a work which will not be done unless money is provided for it by the Government?—Certainly not. The Admiralty are frequently applied to for the advancement of those kind of works; but as they have no funds, they are obliged to go to the Treasury, and the thing falls to the ground generally. Even in the matter of an eclipse expedition, the Admiralty had not the means of fitting one out. If a single individual is sent on an expedition for any purpose not purely naval, in one of Her Majesty's ships, the Admiralty are subjected to ask the Treasury if not to give him a salary, to pay the expenses of his mess, and that puts a difficulty at once in the way, for there is naturally an indisposition to make such requests.

11,598. Do you think that those restrictions are unnecessary?—I should have thought so. I should think that a great department of the Government ought to have the means of doing small things of that kind.

11,599. Can you name any other objects for which you think it would be desirable that the Government money should be expended, say, for instance, in astronomical, magnetical, and meteorological investigations?—Our observatories merely provide for so much of astronomy as is necessary for navigation. There is no provision made for physical astronomy now, and I think it is highly desirable that there should be. The Board of Visitors of the Royal Observatory are now asking the Admiralty to provide for photographic and spectroscopic observations at Greenwich, but the Admiralty cannot do it without going to the Treasury for it, although it may involve only the employment of one additional assistant.

11,600. (*Dr. Sharpey.*) At present collections of natural history are occasionally made by vessels of the navy from abroad, and it has been suggested that if naval officers were made better acquainted with natural history, the opportunities of the service might be turned to better account for the promotion of that branch of science, by making collections. Dr. Carpenter suggested that in the new naval school, which it is contemplated to establish at Greenwich, there should be instruction given in natural history to naval officers; do you approve of that?—I think, of course, that instruction in Natural History would be perfectly unobjectionable, indeed, would be highly useful, but there are great difficulties in making those collections in ships of war generally.

11,601. That has been explained to us, but it is different with surveying ships?—In the surveying service, ships are prepared expressly for scientific research, and we always have made those collections, and very generally there is a naturalist attached to each surveying ship, but I am quite sure that it will be impossible to carry it out to any extent in a regular ship of war.

11,602. The collections that are brought home by ships of the navy are handed over to the British Museum, are they not?—No, not as a rule. The plan which I always adopt is, that if there is a naturalist in the ship, he himself recommends where the collections should go, and with the approval of the Admiralty they are so sent. Some go to the British Museum, and others go to other departments, such as the School of Mines, or to various museums in the country, where they are made use of.

11,603. And are you generally guided by the opinion of the collector himself?—I always have been so myself, subject to consideration and consultation with qualified men, or, where there is no naturalist, I generally judge for myself, aided by the above considerations. I send them to Professors Owen, or Huxley, or Hooker, or others, as I think the case may require.

11,604. With regard to the collections which were made in the voyage to the Straits of Magellan recently, how were they disposed of?—I think that the majority of them were sent to the British Museum, some were sent to Professor Newton, at Cambridge, and a few were sent to Professor Huxley, and the botanical collections to Dr. Hooker at Kew.

11,605. But still a considerable bulk of them was sent to the British Museum?—I think, if I recollect right, that out of about 27 boxes, 13 were sent to the British Museum.

11,606. Have you any remembrance of what was the description of specimens that these boxes contained?—Some of them contained birds, and some of them zoological specimens, others botanical specimens, and there were some fossils and human crania from Patagonia.

11,607. (*Sir John Lubbock.*) On what principle was the division made?—It was made on the recommendation of Dr. Cunningham, who was the naturalist, and I followed his wishes principally. He had been in communication with the societies before he went out, and he ascertained what would be most useful to each.

11,608. Were they sent to Professor Huxley privately, or were they sent to the museum in Jermyn Street?—I believe I wrote myself a letter to Professor Huxley sending them to him; they were the skulls and fossils which Mr. Darwin, through him, had asked me to procure from a particular locality in Patagonia. There was no official communication sent with them. I think I understood from Professor Huxley that they would eventually go to the British Museum when he had done with them. Collections which go to the British Museum never come out of it; therefore, it is desirable, in many instances, that they should be made use of before going in.

11,609. (*Chairman.*) Do you mean to imply that they are not made much use of when they get there?—I imagine not the immediate use which modern science demands; new institutions have grown up since it was the practice to send everything to the British Museum, and it is pretty certain that the National Museum is undermanned.

11,610. (*Sir John Lubbock.*) But are they not described and published?—The general opinion, I believe, is, that they are not immediately made use of for the reasons I have just stated.

11,611. Have you sent other collections there which have not been published?—I could not undertake to say of my own knowledge, but I know that a general belief exists, that they would be made more immediate use of by being sent where they were sent, and we were not at all bound to send them to the British Museum, or to any particular place; we take the best advice and have no interest, but that the collections shall be turned to the best account; I do not think the Admiralty are bound to send them to any particular place.

11,612. (*Professor Stokes.*) You have advocated, I think, the establishment of a rather large consultative body of scientific men; do you contemplate that they should give their services gratuitously, or that they should be remunerated in any way?—I am very much averse to unremunerated services; I do not think they ever answer. I do not see how scientific men can be expected to give their time to the Government without being remunerated, seeing that they are so badly paid and so hardly worked.

11,613. Would you remunerate them by certain salaries, or by fees given as occasion arose?—I should think by salaries.

11,614. Would you contemplate a large portion of the time of those men being given up to the object of advising the Government?—I should think almost all their time, and to carrying out studies and investigations connected with such advice.

11,615. Have you formed any idea as to the number of advisers that would be required?—To represent every department of science I should think that a large number would be required. I am not prepared to say the exact number, but I should say certainly more than 20.

11,616. Have you formed any opinion as to the scale on which they should be remunerated?—I do not think that it would be fair to offer any scientific

Rear-Adm.
G. H. Richards,
C.B., F.R.S.

5 June 1872.

man who gave the greater part of his time to the Government less than 1,000*l.* a year.

11,617. Do you think that the occasions for consultation would so often arise that a large portion of the time of those men would be employed in that way, or do you contemplate their working out special inquiries which might arise from time to time?—I think that, in addition to the questions which would be referred to them, it would be their duty to find work for themselves, in connexion with such subjects.

11,618. Do you mean work which was suggested by the inquiries which were committed to them from time to time?—Yes, or work that they might initiate themselves which it would be desirable to undertake.

11,619. If they were expected to give their whole time or nearly their whole time in this manner to the Government, have you formed any opinion as to what sort of check could be imposed upon them to show that they did give their time?—If there were a minister of science of course they would be responsible to him, and they would make certain periodical reports, I presume, on different subjects, which would be published.

11,620. Would it not often happen that occasions for researches might arise which could be carried out better by other scientific men who were not on this body than by the actual members of the body itself?—Yes, unless it was a large and comprehensive body, I think that would be so.

11,621. Even if there were as many as 20 on it representing all branches of science?—Yes, probably, and there, of course, difficulty would arise, because although all scientific societies now willingly give their help to the Government whenever it is asked for, I do not think that it would be expected that they should give their help to a paid body of their own class without some remuneration. I should explain that Government do not very frequently ask for advice on scientific subjects, probably for two reasons: that they do not like to tax the powers of overworked men without remunerating them, and that the advice would generally entail an expenditure which the Government have not the money for.

11,622. If this body called upon other men of science, who did not belong to it, for researches, would you contemplate an additional expenditure of the public money in that way, or that they should forego a part of their own salaries?—If it is contemplated that they must go for outside advice, I think you might then make the council smaller and remunerate those who give advice by fees, or in any other way that might be thought right.

11,623. If outsiders were employed in that manner, I presume that they would be remunerated by something in the nature of fees, if they were remunerated at all?—I think so.

11,624. Would you contemplate that the consultative body should advise the Government as to the amount of those fees?—Yes, I think that that would probably be the fairest way.

11,625. (*Professor Smith.*) I think you mentioned that the visitors of the observatory at Greenwich had suggested the addition of a branch of observations for the purpose of physical astronomy, have you yourself formed any opinion as to whether that is a branch of observation which could be properly added on to the other duties of the Greenwich Observatory?—I think so, to a limited extent; but if you are going permanently to establish physical observatories, I should prefer to see separate ones. I think that the physical work probably would be better separated from the Royal Observatory.

11,626. You think that the two classes of observations are so distinct in character as to render that desirable?—Of course there is a certain amount of meteorology that must be observed at the astronomical observatory; but it need not be of any extended character.

11,627. Whereas, if any extended series of observations were necessary, observations in physical astronomy would be made?—Yes, no doubt, and I should think it would require an establishment quite equal to the present Royal Observatory, or probably a number of smaller establishments. The Royal Observatory is a very economical establishment. I do not think it costs for salaries and everything connected with it more than 6,000*l.* a year.

11,628. (*Chairman.*) What do you think would be the best mode of appointing the members of the proposed consultative council; would you leave the choice to the minister of science, or would you make it necessary that the scientific societies should be consulted?—No doubt the scientific societies should be consulted.

11,629. Would you give them any voice in the matter?—No, I think that the appointment should rest with the minister himself or with the Government, but the minister would necessarily take advice from the Royal Society and other societies.

11,630. (*Professor Stokes.*) Would you contemplate the appointment being a permanent one, or for a limited number of years, or for the duration in power of the existing ministry?—Certainly it should not be regulated by the existence of the ministry. I am not in favour of life appointments, but I think it should be for a considerable number of years, and renewable.

11,631. (*Sir J. Lubbock.*) Probably you would be of opinion that the period of years need not be the same in every case?—I do not see any reason why it should not. I think five years, renewable, is a very good period.

11,632. Might not some people feel a difficulty in giving up a permanent appointment for one which was only for five years?—When I say "renewable," I mean it in the sense that if a man is in all respects qualified, performs his duties satisfactorily, and retains his health, he would remain in it.

11,632*a*. It would generally be regarded as practically a permanent appointment, would it not, so long as the holder was capable of fulfilling the duties?—Yes, so long as he was capable of fulfilling the duties properly; and then I should decidedly say that such a man would be entitled to a retiring pension.

11,633. (*Chairman.*) Have there been instances where applications have been made by the Admiralty to the Treasury to sanction expenditure on scientific objects, and where the applications have been refused?—I have an idea that there have, but I cannot call to mind any at this moment; it is a perfectly understood thing, however, that they are not to be made very often.

11,634. The Admiralty are unwilling to make applications of the kind, except in cases of pressing urgency?—Yes, unless they are perfectly convinced of the desirability or necessity of the thing. For instance, with respect to the expedition which is proposed to be sent out at the end of this year, of course the arguments used were very convincing in favour of it, and the First Lord of the Admiralty did not hesitate to support it.

11,636. Do you think it might be desirable that a certain sum should be placed annually at the disposal of the Admiralty for application to scientific objects?—Yes, I do; not necessarily to be spent, but to be spent if necessary.

11,637. That would remove, would it not, the necessity of applying to the Treasury in every particular instance?—Yes, and I ought to say that there is a small sum already allowed, which appears under the head of "Rewards and Experiments;" it is a very small sum. I think it is 500*l.*

11,638. I believe, in Colonel Strange's statement respecting the Government institutions connected with science there was an omission made of the hydrographical surveys of Great Britain and foreign countries?—I believe there was.

11,639. Is that a considerable establishment?—Very considerable, indeed; that is to say, it embraces the whole of the surveys of this country, and, I may add, the surveys of the world.

11,640. It is an establishment which has existed for a great many years?—Since 1795, when I think it was first established.

Rear-Adm. G. H. Richards, C.B., F.R.S.

5 June 1872.

11,641. And there is still much work, is there not, for it to do?—Yes, and will always remain so, I think. We have first to gain a general knowledge of the coast of a country, then, as commerce and intercourse increases, more minute surveys are necessary; moreover, the physical changes always in progress necessitate periodical surveys.

11,642. Does that appear in the annual estimates?—Yes, the total expense, I think, is about 70,000*l.* a year for the scientific vote; but you will observe by the estimates that there are many things included in it. The whole of the Greenwich Observatory is included in it, and the Cape of Good Hope Observatory is included in it, and the Naval College and the Educational Establishment of the Admiralty are included in it. I think, altogether, for the hydrographical part, including these institutions, it is about 70,000*l.* a year, and the whole thing is about 100,000*l.* a year. The cost of these ships of war is included in this latter sum, but they also appear in another vote.

11,643. Are a good many ships employed solely in this service?—We have only two now in the Eastern seas, and one in the Red Sea; but we have surveys in Australia and other colonies, which are on a different footing. We hire small vessels for this purpose in Australia and Newfoundland and the West Indies, but the cost of them is defrayed out of the hydrographic vote. I should remark that Australia defrays half the cost of the surveys of her own coasts.

11,644. Is the principal part of the expenditure upon this subject under your control?—Yes, the hydrographic portion is, with the sanction of the Admiralty.

11,645. (*Dr. Sharpey.*) Is the pay of the officers reckoned in the cost of the ships?—Yes, everything; the pay of the officers and men, the wear and tear of the ships, and everything connected with them.

11,646. (*Chairman.*) Are the ships built specially for this service?—No, they are not, I am sorry to say; but, generally speaking, the most suitable that we have are selected and specially fitted for it.

11,647. You think it would be desirable that vessels should be specially constructed for hydrographical purposes?—It would be better, certainly.

11,648. (*Dr. Sharpey.*) Is it usual for a surveying vessel to carry a naturalist?—Very generally, especially whenever she goes to any ground that has not been much investigated, but we are obliged to ask the Treasury for the Naturalist.

11,649. (*Chairman.*) The surveys are usually conducted, are they not, in the most frequented parts of the ocean?—In those parts of the world where commerce is most extended or likely to extend, and which, in consequence, is most frequented by our ships of war and mail vessels; for instance, in Japan, the coast of China, and the Eastern Archipelago.

11,650. They are conducted in places where commercial vessels are likely to resort?—Yes, we are almost entirely guided by that; the survey of a country prepares the way for commerce and civilization.

11,651. Some of the witnesses before the Commission have recommended that the unfrequented parts of the ocean, where trading vessels are not likely ever to be found, should also be examined for certain objects; would you approve of that recommendation?—There is no doubt but that if the money were forthcoming we could, with great advantage, explore a great many places that are not now explored, but practically we consider that we are bound down to a certain sum, and it is my duty to advise their Lordships to expend it where it is most required.

11,652. Has the sum been the same for many years past?—It has varied somewhat according to the views of different Governments; during the last 12 years, the maximum whole cost per annum has been 120,000*l.*, and the minimum 90,000*l.*; for the last four years, the sum expended for hydrographical purposes has stood at about its minimum; in the present year it has been increased 5,000*l.*, on account of the "Challenger" Expedition, granted at the instance of the Royal Society.

11,653. (*Dr. Sharpey.*) The most frequented parts of the ocean have been already surveyed, have they not?—Yes, or are in course of survey. For instance, the Japan survey, which, of itself, is the work of a lifetime.

11,654. (*Chairman.*) Are there any other points on which you would wish to make additions to your evidence?—No. I think I have stated, generally, my views as to the advantages which would accrue to the public from the advance of Science by the Government.

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 7th June 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., LL.D., F.R.S.

H. W. Chisholm, Esq.

7 June 1872.

HENRY W. CHISHOLM, Esq., examined.

11,655. (*Chairman.*) I believe you are the Warden of the Standards?—I am provisionally appointed to execute the duties of that office.

11,656. Have you prepared a paper showing what has been done, from time to time, in this country with a view to establishing the standard weights and measures on a scientific basis, and also showing the present position of the Standards Department?—I have, and beg leave now to present it to the Commission. Reference is made in it to several Reports and papers connected with the subject, some of which I have already laid before the Commission, and I have now brought others with me. The statement which I have prepared is as follows:—

1. Introduction.

"1. In the following paper I propose to refer to the efforts which have been made from time to time by eminent men of science in this country, unconnected with the Government, to establish our standard weights and measures upon a scientific basis, as well as generally to improve our technical and administrative system of weights and measures; to show how far their recommendations have been adopted by the Government and carried into effect; and to lay before the Science Commission some information relating to the present position of the Standards Department, now by law constituted a department of the Board of Trade, so far as relates to its scientific duties, and their bearing on the objects of the Commission.

2. Efforts of scientific men to improve our standard weights and measures.

"2. The improvement of the standard weights and measures of the kingdom, which serve to regulate all the weights and measures in use, not only for commercial but for scientific purposes, has been from a considerable period, more particularly in the interests of science, the object of earnest endeavours on the part of many of our most eminent men of science, independently of any exertions of the Government.

"Their labours for this object are referred to in the papers containing an account of the construction of our new national standards of length and breadth under the superintendence of the Standards Commission of 1843, drawn up by Mr. Airy and Professor W. H. Miller.*

3. Old Exchequer standards constructed with no regard to scientific accuracy.

"3. The legal standards of weights and measures from time immemorial were deposited in H.M. Exchequer. The Exchequer standards actually used from 1588 to 1825, were constructed in pursuance of the order of Queen Elizabeth, and were verified by comparison with the old standards by a jury of the Goldsmiths' Company.† The construction and verification of these standards appear to have been carried out mechanically, without any attempt at scientific accuracy, and the standards of length in particular were only rudely constructed.

4. First application of science to standard wine gallon in 1708.

"4. The first attempt to place any of the Exchequer standards on a scientific basis, would appear to have been in the construction of the new standard wine gallon in 1708, and through its verification by the legal cubic measurement of 231 cubic inches, in pursuance of the Act 5 & 6 Anne, c. 27. There is, however, no record of either the construction or verification of this standard measure. That it was skilfully and carefully made may be seen by inspecting its present condition, and that it was accurately verified is proved from the following results of scientific comparisons since made:

Capacity of standard wine gallon:	cub. in.
In 1758 by Mr. Harris -	231·2
1814 by Dr. Wollaston and Mr. Carr -	230·8
1819 by Dr. Wollaston and Sir Geo. Clerk - -	230·9

5. Scientific verification of standard coal bushel, in 1730.

"5. In 1730, a new standard coal bushel was constructed under 3 Geo. 2, c. 27, of cylindrical form, to contain a Winchester bushel and a quart of water. Though of rude construction, as compared with Queen Anne's wine gallon, it appears to have been tested by the most eminent men of science of that day, its certificate of verification bearing the signatures of

Edmond Halley.
James Hodgson.
J. The. Desaguliers.

6. Royal Society's standard yard constructed in 1742.

"6. In 1742, scientific men, for want of a better standard of length than the legal standard yard of the Exchequer, proceeded to construct one of their own, and the new standard yard of the Royal Society was constructed for them by Mr. Graham,‡ by comparison with all the existing standard yards of best repute. The length of the yard was defined upon a brass bar by two points or dots, and the equivalent of the Exchequer standard was also marked upon the bar, being more than $\frac{1}{100}$ inch deficient in length, as compared with the Royal Society's standard.

7. New standards by order of the Commons' Committee of 1758.

"7. In 1758, the improvement of the national standards was taken up by a Committee of the House of Commons, who reported in 1758 and 1759, and made many recommendations on the subject of the existing system of weights and measures. Under their directions, three new standard yards, similar to the Royal Society's standard, and considered to be identical with it in length, were constructed by Mr. Bird. At the same time, three new standard troy pounds were constructed by Mr. Harris, from the troy 8 oz. and 4 oz. Exchequer standards, corrected by adding $1\frac{1}{4}$ grain, the estimated loss of their original weight from use, as determined from comparisons made with standard troy weights belonging to the Mint and some of the scale-makers. These new standards were deposited with the Clerk of the House of Commons, but no practical effect was given to the other recommendations of the Committee.

8. Ordnance Survey operations based on Royal Society's standard in 1785.

"8. In 1785, the first geodesical operations were begun upon which the Ordnance Survey of the United Kingdom has since been founded, by General Roy's measurement of the base on Hounslow Heath. The standard used in the first instance for this purpose was that known as General Roy's scale, 42 inches in length, divided into tenths, and constructed by Mr. Bird. This scale was based, not on the legal Exchequer standard, but upon the Royal Society's standard yard, with which the whole length of 36 inches of General Roy's scale was compared and found to agree.* Points at the distance of 40 inches from each other were laid off from General Roy's scale upon the 20 feet standard measure actually used, without any verification of the supplementary 4 inches, and from this measure the length of the glass rods was determined with which the base on Hounslow Heath was measured.

9. Shuckburgh's standard scale constructed in 1798.

"9. More important scientific operations for the improvement of the standards were undertaken by Sir Geo. Shuckburgh in 1798. A new subdivided measure of 60 inches, known as 'Shuckburgh's scale,'† was constructed under his directions, with fine lines; together with a comparing apparatus, consisting of a bar carrying micrometer microscopes. This is stated to have been the first occasion on which this mode of comparison was adopted, beam-compasses having been previously used, having fine points to be adjusted to the dots in the measuring bar. Shuckburgh's scale was subsequently adopted as the scientific standard, as distinguished from the existing legal standard of the Exchequer.

It may here be interesting to cite the results of the following measurements made by Sir G. Shuckburgh,‡ in terms of 36 inches of this scale:—

		Inches.
Exchequer yard of Henry VII.	=	35·924
" Queen Elizabeth	=	36·015
Royal Society's yard of 1642	=	36·0013
" Exchequer line on	=	35·9933
Bird's Parliamentary Standard, 1758	=	36·00023
36 in. of General Roy's scale	=	36·00036

10. His determination of weight of cubic inch of water.

"10. A further scientific operation was also carried out in 1798 by Sir Geo. Shuckburgh, by which the weight of a cubic inch of water was determined, viz., one cubic inch of distilled water weighed in air ($t. = 62°$ F. $b. = 30$ in.), against brass weights = 252·458 grains. It is upon this determination that our measures of capacity, and also the gas measuring standards, have since been based, and have been defined by law.

It is, consequently, of much importance that no doubt should exist of the scientific accuracy of such determination, more particularly as any error must necessarily be multiplied 1,728 times when applied to the cubic foot.

Unfortunately there exists much doubt as to its accuracy, and an authoritative scientific re-determination of the weight of a cubic inch of distilled water is very desirable at the present time. Other determinations, hitherto made, show the following discordances from Sir G. Shuckburgh (although his *linear measurements* were confirmed by Kater in 1824), both in regard to the imperial weight of a cubic inch of water as stated above, and also to the relative metric weight of a cubic decimetre of distilled water at its maximum density (or $t. = 4°$ $c.$) weighed in a vacuum.

Date of Determination.	By whom determined.	Imperial Weight of Cubic Inch of Water.	Metric Weight of Cubic Decimetre of Water.
		Grains.	Kilogram.
1795	Lefevre-Gineau, in France	252·337	1000·000
1798	Shuckburgh, in England - -	252·458	1000·480
1825	Berzelius, Svanberg, and Akermann, in Sweden	252·411	1000·296
1830	Stampfer, in Austria	252·249	999·653
1841	Kuppfer, in Russia	252·334	999·989

---

* Phil. Trans. 1856, Part III. 1857, Part III.
† Rep. of Committee of 1758. 115 1864, p. 9.
‡ Phil. Trans. 1742-3, p. 185, &c.

* Phil. Trans. Part I., p. 75.
† Phil Trans. 1785, p. 135, &c.
‡ Phil Trans. 1821, Part I., p. 182.

11. Scientific evidence before Commons' Committee of 1814.

"11. More strenuous endeavours on the part of scientific men were commenced in 1814 for the improvement of our standards, and by Sir George Clerk, then a member of the House of Commons. A select committee was appointed to consider the subject, and the evidence of Professor Playfair and Dr. Wollaston was given before them, and is appended to their Report,* defining the relations of the length of a pendulum vibrating seconds to the standard yard. Bills were brought in during the next two sessions, but no legislation took place.

12. Comparison of Imperial and metric standards of length by Royal Society in 1816.

"12. In 1816, on the motion of Mr. Davies Gilbert, a resolution of the House of Commons was passed for comparing the Imperial standard yard of 1758 with the primary standard metre at Paris, and the comparison was entrusted by the Government to the Royal Society, who appointed a committee of their body for that purpose, and requested the assistance of the Academy of Sciences at Paris. The result was the construction of the two platinum metres now in possession of the Royal Society, the most authoritative standard measures of metric length now in this country, from one of which, the line standard, the length of the subdivided standard metre of the Standards Department was laid down by Messrs. Troughton and Simms in 1867. So far as I am aware, this has been the only occasion in which the aid of the Royal Society, as a scientific body, has been requested by the Government, and has been given in any matter relating to standards of weights and measures.

See App. IX. to the Fifth Rep. Stand. Com., p. 148.

13. Royal Commission of scientific men in 1819.

"13. In 1819. a Royal Commission was appointed upon the subject of weights and measures, consisting of the following eminent men of science:—

Sir Joseph Banks.
Sir Geo. Clerk.
Davies Gilbert.
Dr. Wollaston.
Dr. Thomas Young, and
Captain Henry Kater.

"Three reports† were made by this Commission within the next two years, and in 1822 a bill was introduced into Parliament to carry out their recommendations. The bill was eventually passed in 1824, as the Act 5 Geo. IV. c. 74, and it was in pursuance of the provisions of this Act that our existing official standards were constructed and verified.

14. Consequent construction and verification of new Exchequer Standards under Act of 1824.

"14. The legal units of measure and weight were declared by this Act to be one of the standard yards and one of the troy pounds constructed under the direction of the Committee of 1758. New Exchequer secondary standards, to be substituted for the old standards of Queen Elizabeth, were constructed under the immediate superintendence of Captain Kater, more scientific methods being adopted by him for their accurate verification. The new Exchequer yard was, however, not laid down from the new legal standard yard, which together with the new legal standard pound were directed to be left in the custody of the Clerk of the House of Commons, but from the Shuckburgh standard yard, which was considered by Captain Kater to be identical with it.

"The account of the construction of the new Exchequer standards by Captain Kater is given in the Philosophical Transactions of the Royal Society.‡ It was thus that, for the first time, the actual standards of the weights and measures throughout the kingdom were constructed and verified on scientific principles, under the directions of the Commission of 1819.

15. Destruction of Imperial standards in 1834.

"15. In 1834, the legally constituted imperial standard yard and pound were destroyed in the fire which occurred at the Houses of Parliament, and in 1838 a Committee was appointed by the Treasury to consider the steps that ought to be taken for determining new standards.

16. Report of Scientific Committee for their restoration in 1841.

"16. This standards Committee was composed of the following men of science:—

Mr. Airy, Astronomer Royal, Chairman.
„ F. Baily.
„ J. D. Bethune.
„ Davies Gilbert.
„ J. S. Lefevre.
„ J. W. Lubbock.
The Rev. Geo. Peacock.
„ Rev. R. Sheepshanks.

"Their report, dated 21st December 1841, contains many important recommendations, not only on the construction of standards, but also on the general subject of standard weights and measures.

17. Report of Commission for constructing new standards in 1854.

"17. The members of the Committee of 1838 were reappointed in 1843, as a Commission for constructing the new standards of length and weight, together with

The Marquis of Northampton, F.R.S.,
Lord Wrottesley, and
Professor W. H. Miller.

"On the death of the Marquis of Northampton in 1851, the Earl of Rosse, his successor as President of the Royal Society, was appointed a member of the commission in his stead.

"It was not until 1854 that the labours of this standards commission terminated. Their report is dated 28th March 1854, and states the completion of the new Imperial standards and their deposit at the Exchequer. A more full and detailed account of the construction and verification of the new standard yard and pound is contained in the before-mentioned papers by the Astronomer Royal and Professor Miller, printed in the Philosophical Transactions of the Royal Society.

18. Their recommendations for improvement of Standards Department.

"18. In the above-mentioned reports of 1841 and 1854, many other recommendations were contained relating to the improvement of the weights and measures office of the Exchequer, and generally of the mode of dealing with weights and measures throughout the country.

"The Exchequer weights and measures office consisted of only two subordinate clerks, and their functions were limited to the comparison by the ordinary method of such local standards as were sent from time to time to be compared with the Exchequer standards. A set of balances of ordinary construction constituted the only apparatus, and no attempt was made to call in the aid of science to these comparisons.

"One result of this insignificant position was, that no means existed of any reverification from time to time of the Exchequer standards in use from 1824, the great importance of which was pointed out by the commission.

19. Neglect of these recommendations by the Government.

"19. No step whatever was, however, taken by the Government to carry out these recommendations, although in 1859 the attention of the Treasury was called to the subject by the Comptroller-General of the Exchequer and by the Astronomer Royal, in two letters which were printed and laid before Parliament.* In referring to the report of 1841, the Comptroller-General, Lord Monteagle, stated that it was almost inconceivable that this important document, and the evidence subjoined to it, should not for 17 years have attracted the attention and notice of successive governments and of the legislature. Meanwhile, the new standards were left undisturbed in their cases in the strong room of the Exchequer, without any attempt whatever being made to render them serviceable, or to ascertain what relation the Exchequer secondary standards bore to them.

20. More accurate balances furnished to the department.

"20. An important addition was, however, made to the apparatus of the weights and measures office in consequence of the report of the Commission in 1854, a set of new balances of the best construction being furnished. These balances were more immediately required for verifying copies of the new standard decimal bullion weights constructed under the superintendence of the commission, and verified with the highest scientific accuracy by Professor W. H. Miller. These standards were legalised in 1853 by 16 Vict. c. 29.

---

* 290/1814.

† 585/1819. 311/1820. 3/1821.

‡ Phil. Trans. 1826, Part I.

* 188/1859.

21. Scientific aid required for constructing new gas measuring standards in 1859.

"21. In 1859, under the sale of gas Act, 22 & 23 Vict. c. 26, new gas measuring Exchequer standards were directed to be constructed. Several eminent men of science were consulted by the Comptroller-General as to the best method to be pursued for the construction of these new standards of volume, and eventually it was carried out, though not without considerable difficulties, under the immediate superintendence of the Astronomer Royal, the standards being accurately verified by him and Professor Miller. Copies have since been verified for the use of inspectors of gas meters, for the regulation of all meters in use in the United Kingdom. These standards are scientific instruments for measuring volumes of gas or air, and their use involves the necessity of strict attention to the density, temperature, and hygrometric condition of the air, and the measure of pressure of gravity applied to it, as well as to the temperature and consequent dilatation of the material of the standards.

22. New standards department recommended by Commons Committee of 1862.

"22. In 1862 a Select Committee of the House of Commons was appointed on the subject of weights and measures. In their report,* after recommending the introduction of the metric system, they further urged the necessity of establishing a more authoritative department of weights and measures, in connexion with the Board of Trade.

23. Mr. Chisholm's Report on Standard Weights and Measures in 1863.

"23. In the same year, the writer of this paper was appointed chief clerk of the Exchequer, and in the discharge of his duties, his attention was directed to the neglected subject of the standards. The first result of his inquiries was the preparation of a full report upon the whole subject to the Comptroller-General of the Exchequer, dated 3rd June 1863, which was afterwards printed and laid before Parliament.†

24. Apprehended injury to new standard pound in 1864.

"24. The next step taken was to open, in January 1864, for the first time since their deposit in 1853, the cases in which the Imperial standards were contained. The standard yard was ascertained to be in good condition, but the standard platinum pound was found to be completely covered over with decayed matter arising from decomposed glue and leather which had been used for lining the case, and it was feared that it was injured as a standard weight.

25. Report of revived Standards Commission, and further recommendations.

"25. The surviving members of the Scientific Commission of 1843 were consequently again called together by the Treasury and requested to examine into the state of the standard pound weight. In their report, dated 14th July 1864, after stating the means used for cleaning the standard, and its being found to be uninjured, they further called the attention of the Treasury to the discreditable state of the Weights and Measures Office, and the absolute necessity of carrying out the repeated recommendations which had been made from time to time for establishing a new and substantive Standards Department under a responsible chief officer.

26. Abolition of Exchequer office, and establishment of Standards Department of the Board of Trade in 1866.

"26. Again, however, the matter was allowed to rest until, 1866, when, in consequence of the abolition of the old office of the Exchequer as a separate department of Government, and its amalgamation with the Audit Office, it became absolutely necessary to make provision for the duties connected with the standard weights and measures. As the writer of this paper was one of the committee appointed by the Treasury to make all the arrangements consequent on the abolition of the Comptroller-General's office, he was thus enabled personally to press the subject of the standards upon the Treasury authorities, and was requested to draw up a draft minute for carrying out the recommendations which had been made from time to time. This minute was subsequently adopted by the Treasury, a clause being added relating to Mr. Chisholm being placed at the head of the department; and in pursuance of the Treasury minute, dated 26th February 1866 (*see* copy appended to the First Report of the Warden of the Standards), the Act 29 & 30 Vict. c. 82 was passed, under which the new Standard Weights and Measures Department of the Board of Trade was established.

27. Scientific duties imposed by s. 11 of Standards Act.

"27. S. 11 of this Act, imposing upon the Warden of the Standards the duty of conducting comparisons of standards *in aid of scientific researches*, was added in the House of Lords on the motion of Lord Wrottesley, on the express ground that as so large a part had been taken by men of science in the improvement of the national standards and their administration, it was right that the new department should be made available for the interests of science.

28. Provisional arrangements for the new department.

"28. The Act was passed in August 1866, and took immediate effect; it was, therefore, necessary at once to make arrangements for the performance of the duties of the new department. A merely provisional arrangement, however, was made by the Board of Trade and concurred in by the Treasury, under which all the duties relating to the standards were continued to be performed, as before, under the direction of Mr. Chisholm (who had been obliged to take a more active part in them in consequence of the retirement of the senior clerk of the Weights and Measures Office of the Exchequer), and by Mr. Chaney, then junior clerk. They were constituted 'Officers of the Board of Trade,' and placed under the 'Commercial Department.' The mode in which this provisional arrangement was carried out is contained in a parliamentary paper laid before the House of Commons in 1867, on the Board of Trade.*

29. Royal Commission on Standard Weights and Measures in 1867.

"29. In order that the duties of the new department, including the verification of the standards, should be established and carried out 'under high 'scientific supervision,' as had been recommended by Lord Monteagle in his letter of 9th February 1859, a new Royal Commission was appointed on 9th May 1867, to examine and report upon the whole subject, consisting of the following scientific members of the former Commission:—

The Astronomer Royal, Chairman,
Earl of Rosse,
Lord Wrottesley,
Sir J. Shaw Lefevre,
General Sabine, F.R.S.,
Mr. T. Graham,
Professor W. H. Miller,

together with Mr. Chisholm. In the following year, upon the deaths of the Earl of Rosse and Lord Wrottesley, Lord Colchester and Mr. S. Cave, M.P. (then Vice-President of the Board of Trade) were added.

30. Their five Reports and recommendations, 1868-70.

"30. Five reports were made by the Commission; the final report, upon the duties and business of the Standards Department, being dated 3rd August 1870. The minutes of proceedings of the Commission are appended to this report, together with a number of papers describing the scientific instruments and operations of the department in relation to the verification of standards. In a postscript to this report, in which Mr. Chisholm took no part, the Commission expressed their opinion as to the permanent establishment of the department, for which a provisional arrangement had been made. They also recommended that a comprehensive Act should be passed for amending and consolidating all the weights and measures laws, and carrying out such of their recommendations as required legislative sanction.

31. No alteration yet made in provisional arrangements of the department.

"31. No effective steps whatever have, however, been yet taken by the Board of Trade for these objects; and, notwithstanding the express provisions of the Standards Act of 1866, and the recommendations of the Commission, no formal constitution of the Standards Department, or appointment of the Warden of the Standards, or of any officer of the Standards Department, has hitherto been made by the Board of

---

* 411/1862.

† 115/1864.

* 47/1867.

H. W. Chisholm, Esq.

7 June 1872.

Trade. The provisional arrangement of 1866 has since been continued without any alteration, except that the 'Commercial Department' of the Board of Trade, having been abolished on 31st March 1872, the provisional officers of the Standards Department have been placed under the 'Harbour Department.'

32. Continued neglect of recommendations of scientific men.

"32. It will thus be seen that, however strenuous have been the efforts of scientific men to establish both the Standards of Weights and Measures and a Standards Department upon a scientific basis, still it has been only after the lapse of a long period, and after repeated recommendations to the same effect were made, that the subject has met with attention and been in any way dealt with on the part of the Government. Indeed, this apathy was felt so strongly by the Astronomer Royal, who has been foremost in proposing improvements of our standards system, that he was led, as I understand, to say that 'of all the 'powers that he has had to do with, he never 'met with any resistance so difficult to be overcome 'as the *vis inertiæ* of the Government.' So far as standard weights and measures are concerned, this neglect is partly attributable to the dry and uninviting nature of the many details involved in the subject, and partly to the time and attention of the members of the Government being so fully occupied with other matters pressing upon them which are more immediately connected with political and party questions. It is right, however, to add that, since 1866, the sanction of the Board of Trade and of the Treasury has never been withheld from the large expenditure required for new scientific instruments and standard apparatus of various kinds, under the recommendations of the Commission, with which the department is now supplied or being supplied.

33. Appointment of delegates to International Metric Commission at Paris.

"33. As a further example of the disinclination of the Government of this country to have anything to do with scientific matters relating to standard weights and measures, I may here quote the case of the appointment of delegates from this country to the International Commission at Paris for the construction and verification of new international metric standards, with all the best appliances of modern science.* The French section of the Commission was appointed in 1869, consisting of eight members, all eminent in science, and with two exceptions, members of the Institute of France. When the invitation of the French Government to foreign Governments to send men of science, as representatives, to take part in this International Commission† reached this country, it was referred to the Standards Commission then sitting, and a resolution was passed by them recommending its cordial acceptance, and that three members of the Commission should be nominated as delegates from this country, viz., the Astronomer Royal, Professor Miller, and Mr. Chisholm. Although this recommendation was approved and forwarded to the Treasury by the Board of Trade, the result was that an official communication was made by our Government to the French Government, declining to take any part in the proposed International Commission, on the ground that the metric system was not legal in this country; and, as may be seen from the papers appended on the subject to the Fifth Report of the Standards Commission, it was not until after the matter had been strongly pressed upon the Treasury by the Standards Commission and by the Board of Trade, that the Government was induced to reconsider their decision, and consent to the nomination of the three delegates proposed by the Commission. As this International Metric Commission comprises many of the most eminent men of science from 22 of the principal countries of the civilized world, the effect of the first decision of the British Government would have been to isolate this country, and prevent its taking part in working out this international question, notwithstanding its importance both in a commercial and in a scientific point of view.

34. Question as to *temporary* appointment of Standards Commission in 1867.

"34. It may be observed that the Standards Commission, of which the Astronomer Royal has been chairman, has been called together on four different occasions, and for different objects connected with standard weights and measures, though appointed each time as a temporary Commission only. On the last occasion of its appointment, when the Commission held its first meeting on 18th June 1867, the question was debated how far it was to be considered as a temporary Commission, some of its objects being to a certain extent continuous or recurring. It was agreed, however, that it was a temporary Commission, according to the terms of Her Majesty's appointment, although after its close, when the existing objects were attained, it might, perhaps, be again revived for special occasions. This view met with the concurrence of the Treasury authorities. The question was again referred to by the Commission at their meeting on 16th July 1870, to consider their fifth and final report, when a similar opinion was held by them.

25. Necessity of scientific aid in performance of duties of Standards Department.

"35. In point of fact, as stated at the conclusion my Fifth Annual Report for 1870–1, it would hardly have been possible for the officers of this department to have performed the new scientific duties assigned to them by the Standards Act of 1866, without the aid and counsel of those distinguished members of the Commission who had previously given so much attention to these questions of metrological science, more particularly the Astronomer Royal and Professor Miller; and although the Standards Commission has been brought to a close, there have been since many occasions on which their advice and assistance have been needed and cheerfully given, when scientific difficulties have arisen in the department. It is certain also that if the time ever arrives when the recommendations of the Commission for the improvement of our system of standards and of weights and measures in general are to be practically carried into effect under legislative authority, similar scientific aid and counsel will be absolutely required to a considerable extent, not only for scientific operations within the office, but also more particularly for drawing up a code of regulations and instructions in regard to the mode of constructing and verifying weights and measures, as well as instruments connected with them, according to an uniform system throughout the country, so far as scientific principles are involved in the technical details of such regulations.

36. Practice of other countries as to scientific aid.

"36. The necessity of this scientific aid and support will at once be seen from observing what has been done in other countries, where the national system of weights and measures, and an uniform legal method of constructing and verifying them, as well as balances, have been established on a scientific basis.

37. In France.

"37. In France, the metric system was first established by law at the close of the last century, in pursuance of the recommendations of a Scientific Commission, to which all foreign countries were invited to send men of science as delegates, and to take part in the work of the Commission. At the present time the principal weights and measures department of France is the Conservatoire des Arts et Métiers at Paris, a branch of the Ministère du Commerce, &c., and of which General Morin, a member of the Institute, is director, and M. Tresca, an eminent man of science, sub-director. They are aided by a Council, amongst whom are many other eminent scientific men, and information upon the subject is also diffused by means of scientific lectures, as may be seen from the following extracts from the Annuaire-Almanac du Commerce, 1870:

"'Conseil Supérieur du Commerce, de l'Agriculture
"et de l'Industrie.

"'Ce conseil donne ses avis sur toutes les questions que le Gouvernement juge à propos de lui renvoyer.

---

* See Appendix to Fifth Report Standards Commission, p. 38.

† Minutes of 2nd Dec. 1869, s. 3, 4. Min. 2nd April 1870, s. 10

H. W. Chisholm, Esq.

7 June 1872.

* * S'il y a lieu de constater certains faits, le conseil peut entendre les personnes qu'il sait devoir l'éclairer; il peut même, s'il y a besoin, procéder à des enquêtes, avec l'autorization du Ministre.

" 'Président, le Ministre de l'Agriculture et du Commerce."

" The council consists of 27 members, amongst them members of the Senate, Legislative Assembly, heads of Departments, &c., and includes—

" Dumas, G., Membre de l'Institut.
" Michel Chevalier, G.O., do.

" The Conseil Général de l'Agriculture consists of 89 members, nominated by the Local Chambers of Agriculture, and of 10 members nominated by the Government. Amongst them—

" Dumas, G., Membre de l'Institut.
" Baron Charles Dupin, G.O., do.
" Boussingault, G., do.
" Chevreul, G.O., do.

" The Comité Consultatif des Arts et Manufactures consists of 16 members, and amongst them—

" Chevreul, G.O., Membre de l'Institut, President.
" Regnault, C., do.
" Combes, C., do., Inspecteur-Général des Mines.
" Bareswil, O., Chimiste, Secrétaire du Comité.

" The scientific lectures are referred to under the following head :—

" 'Conservatoire des Arts et Métiers.
" 'Cours public. Haut enseignement.

" 'Professeurs :

" 'Baron C. Dupin, Membre des Institut, Géométrie appliquée aux Arts.
" 'De la Gournerie, Ingénieur-en-Chef des Ponts et Chaussées, Géométrie descriptive.
" 'Tresca, H., Sous-Directeur du Conservatoire, Mécanique appliquée aux Arts.
" 'Trélat, E., Constructions Civiles.
" 'Becquerel, E., Membre de l'Institut, Physique appliquée aux Arts.
" 'Peligot, E., Membre de l'Institut, Chimie appliquée aux Arts.
" 'Payen, C., Membre de l'Institut, Chimie appliquée à l'Agriculture.
" 'Boussingault, C., Membre de l'Institut, Chémie Agricole.
" 'Mole, O., Agriculture.
" 'Mangon, O., Ingénieur-en-Chef des Ponts et Chaussées, Travaux agricoles et Génie rural.
" 'Alcan, Filature et tissage.
" 'De Lignes, Chimie appliquée aux Industries de la Teinture de la Céramique, et de la Verrerie.
" 'Wolowski, O., Membre de l'Institut, Economie Publique et Législation Industrielle.
" 'Burat, Jules, Economie Industrielle et Statitique.' "

38. In North Germany.

"38. Again, in North Germany, under the law of 17th August 1868, for introducing the metric system into the North German Confederation, permissively from 1st January 1870, and exclusively and compulsorily from 1st January 1872, the administration of weights and measures is placed under the authority of a permanent Central Standards Commission, sitting at Berlin, consisting of the following members :—

" Professor Dr. Förster, Director of the Observatory at Berlin, President.
" Privy Councillor Dr. Hülsse, Director of the Polytechnic School at Dresden.
" Privy Councillor Dr. Karmarsch, Director of the Polytechnic School at Hanover.
" Professor Dr. von Baur, Director of the Polytechnic School at Stuttgart.
" Professor Dr. Schönfeld, Director of the Observatory, Mannheim.
" Dr. G. Karsten, Professor of Physics in the University of Kiel.
" Herr G. Repsold, Mechanician and Supervisor of Verification at Homburg.
" Privy Councillor Dr. Stüve, Consulting Officer in the Prussian Ministry of Commerce.
" Herr Baumann, Consulting Mechanician and Verifying Officer at Berlin.

" A distinct Standards Commission, with similar powers, is to be appointed for the kingdom of Bavaria, which forms part of the German Empire, under the German law of 21st November 1871. By this law the metric system is made permissive in Bavaria from 1st January 1872, and compulsory from 1st January 1878.

39. In Austria.

"39. So again by the Austrian law of 23rd July 1871, by which the metric system is to be introduced into the Austrian Empire permissively from 1st January 1873, and compulsory from 1st January 1876, an Imperial Standards Commission is to be appointed, to hold its sittings at Vienna, and to be the highest administrative authority for weights and measures.

40. In the United States of America.

"40. An analogous case may be seen in the United States of America, where the standard weights and measures have for some time been established on a scientific basis, and placed under the superintendence of men of science, who have the management of the Coast Survey. The construction and verification of alcoholmeters is entrusted to the Weights and Measures Department at Washington, and considerable alterations have recently been made in these instruments, in pursuance of a report of the National Academy of Sciences, to whom the question was referred by the United States Government.

41. Further instances in preparing new standard trial plates for gold and silver coin.

"41. I may also here refer, as a further illustration of the subject, to another branch of the duties of the department, involving the necessity of scientific knowledge for its due performance, which has been imposed upon me since the close of the Standards Commission.

" The testing of the due weight and fineness of the gold and silver coins of the realm at certain periods by a formal examination, independent of the Mint, has been an established practice in this country from time immemorial, and is known as the " Trial of the Pyx." A full report upon this subject was drawn up by me in 1866,* and was presented and laid before Parliament. For determining this test, standard gold and silver trial plates have always been used, and were formerly entrusted to the custody of the Exchequer. Under the Standards Act of 1866, the custody of and duties relating to these standard trial plates were transferred to the new Standards Department, together with the weights and measures.

"Under the Coinage Act, 1870, together with some special duties relating to standard weights for each coin of the realm, the duty of *preparing* new standard trial plates was imposed upon this department; and, in the First Report of the Master of the Mint for 1870, it was stated that the existing trial plates, which had been constructed in 1829 by the Goldsmiths' Company, according to former precedents, were wanting in accuracy, and that it was necessary that new plates should be made. In fact, it was also shown that all the standard trial plates, which had been made since Sir Isaac Newton was Master of the Mint, in the reign of Charles II., were more or less inaccurate. This statement was brought last year by the Treasury under the consideration of the Board of Trade, who directed me, accordingly, to prepare new plates, in pursuance of the Act.

" Upon consulting with the Mint officers, we agreed that it was most desirable to call in the aid of the best scientific information for the construction and verification of the new trial plates. I first appealed to Dr. Percy, as the best authority on metallurgy, and learned from him (as, indeed, I have since had further opportunities of ascertaining from my experience as a member of the International Metric Commission at Paris, through M. Henri Saint Claire Deville) that there are few more difficult problems to solve than the making and verifying a thoroughly homogeneous alloy of two metals differing materially

---

* 3186.

H. W. Chisholm, Esq.

7 June 1872.

in density, such as gold and copper, and of mixing them with strict accuracy in the definite proportions required.

"Under these circumstances, I hoped to obtain the scientific aid so desirable for the proper performance of my duty, by applying to the Astronomer Royal, not only as having been chairman of the Standards Commission, and having some cognizance of the subject, but also as President of the Royal Society, the highest scientific body in the kingdom, from amongst whom, as it appeared to me, the desired assistance might, if anywhere, be obtained. After some correspondence, however, and some consideration given to the subject, the Astronomer Royal declined to interfere in any way, unless specially called upon to do so by the Government. I have been thus obliged to act in the matter without the advantage of being aided by any scientific authority, and could do no more than entrust the construction and verification of the new standard plates, as on former occasions, to the technical skill and scientific knowledge of the officers of the Mint and of the Goldsmiths' Company.

"42. From what has been here stated, it is obvious that so far as relates to all scientific duties of the Standards Department, and their efficient performance, the aid, support, and sanction to be afforded by the establishment of a permanent Scientific Commission, or Council with defined authoritative functions, recognized by the Government and by Parliament, is most desirable. As to these departmental duties generally, I would beg to refer the Commission to the many scientific details of the operations of the department which have been actually performed since 1866, as shown in the papers appended to the Fifth Report of the Standards Commission, more particularly the reverification of the old standards, and the original verification of new standards; and to invite their inspection of the collection of scientific instruments, as well as of books of a scientific, historical, or technical character, in any way relating to weights and measures, and their standards, which have already been provided in the Standards Department.

43. Reference to paper on weights and measures taught in schools.

"43. In conclusion, I beg to lay before the Commission, as bearing upon the question of Scientific Instruction, a paper upon the teaching of weights and measures in schools, which has been drawn up by Mr. Chaney, and refers to some points which may deserve consideration.

With respect to teaching by drawings and models of weights and measures, I would also draw the attention of the Commission to the printed charts now in the Standards Department, illustrating the forms and sizes of the several denominations of metric weights and measures, which have been circulated in Germany by the North German Standards Commission; and also to the collection of models of metric weights and measures, as well as of apparatus connected with them, all neatly packed in a box, which has been constructed under the sanction of the French Government for the use of schools in France, and is delivered from the manufactory at Paris to any railway station in France, at a total cost of 75 f., or 3*l.* sterling. Some time since, I brought this mode adopted in France for teaching the use of weights and measures in schools under the notice of the Committee of Privy Council for Education, and sent the box of models for their inspection. It has since been returned to the Standards office.

The Teaching of Weights and Measures in Schools.

"I wish to direct attention to the present rude and antiquated method of teaching weights and measures in schools, and to the necessity of providing instruction therein more in accordance with the requirements of science.

1. Presen method o teaching "weights and measures" in schools.

"1. Evidence of the manner in which weights and measures are generally taught in schools may be found in the modern text books on arithmetic,* and also in the instructions issued by the Committee of Council on Education in their Report for 1870–1, p. cxxxix., which direct 'that arithmetic must include the present 'system of weights and measures, but there is no 'need to make it unduly onerous;' as well as the principles of the metric system of weights and measures herein-after referred to.

"The earliest arithmetic books, such as those of Record, Jeake, and Cocker, are really only cambists, or commercial dictionaries, being mostly occupied with accounts of weights, measures, coins, and exchanges of the various countries of the world. Subsequent arithmetic books afford a glimpse of the true principles of arithmetic, but are still encumbered by numerous tables of exchanges, weights and measures of foreign countries, bills of parcels, &c., their only aim being 'to teach the use of weights and measures, and reckonings in all sorts of bargains.'

"In the best modern arithmetic books, weights and measures occupy but a few pages, although their use necessarily extends throughout most of the exercises, and these few pages present a collection of trade terms, and local or customary weights and measures, which should find their place rather in books of reference, dictionaries, cambists, and ready reckoners. Two thirds of the weights and measures now mentioned in printed arithmetic books are obsolete, or purely local, and the use of some of them is expressly forbidden by law. As an example of the manner in which weights and measures are thus taught, I select one of the best modern arithmetic books, published at Cambridge in 1870, and the first book of arithmetic published by the Commissioners of National Education in Ireland. From these it appears that a student is required to learn troy weight, stated to be used not only in weighing gold and other precious metals, but also in determining specific gravities, and 'generally 'in philosophical investigations;' then diamond weight, and apothecaries' weight, where he may become acquainted with the mystic signs ℈, ʒ, ℥. He is then conducted through avoirdupois weight, and, amongst other things, learns that 8 lbs. make a stone of butchers' meat (by 5 & 6 Wm. IV. c. 63, the stone is expressly declared to be equal to 14 pounds in all cases), that 19½ lbs. make a fodder of lead, 24 ounces a great pound of silk; next follows a long series of wool weights. The student ascends the table of linear measures from barleycorns to degrees. He learns horse measure; coal measure (although the law directs that all coals are to be weighed), and drapers' measure, next invite his attention; and it is curious that, out of the foreign measures generally given in arithmetic books, the only one here given is that of the 'Flemish ell of 'cloth,' a measure which expired 40 years ago. Measures of surface and solidity follow, the measure of a hide being even stated. (Jeakes in 1701 said the hide was then obsolete.) Next come separate tables for wine, ale, and beer, and corn measure, the contents of a tierce, anker, runlet, &c., of wine, a tun of beer, a coomb, last, or strike of corn, and many such other obsolete terms being given.

"Setting aside the fact that such trade terms and local and customary weights and measures are never remembered by the student after he leaves school, for what is never applied to use is soon forgotten, is it desirable that, to the hindrance of more eligible subjects, a student should be occupied in learning or writing exercises in weights and measures, many of which are forbidden by law?

"It is probable that the continued repetition of all these old local and customary weights, &c., in books of arithmetic has done much to damage the reputation of the Imperial system of weights and measures; and, in fact, it led the Committee of the House of

---

* The library of the South Kensington Museum contains an excellent collection of arithmetic books.

Commons, in their Report of 1862, to class a number of these obsolete weights and measures as existing and legal.

2. Weights and measures to be taught by means of object lessons and models.

"2. Again, the student is never enlightened as to the denomination and proportion of the weights and measures he actually sees in shops and public places; these necessarily differ from the units arranged in the tables, but a knowledge of them is quite as important as the units themselves. In the normal schools of France, a small collection of legal weights and measures, including a pair of scales arranged in a box, is provided, in order that they may be placed before the student; and in this country it would be far more instructive and interesting to the student if models were placed before him of all the imperial weights and measures which he sees in use in shops and public places, with the means of comparing them. A systematic course of object lessons thus given would facilitate the instruction in the rudiments of physical science urged by the Commission in their Second Report (Scientific Instruction, 1872). Mr. Cornish, inspector of schools, in his recent general report to the Council of Education, says, 'School managers 'would do well to adopt an old suggestion, and provide their schools with such of the standard weights 'and measures as they conveniently can; a few hours 'weighing and measuring would make the children 'more at home with them than many hours of bare 'learning the tables.'

"As an instance of the antiquated manner in which weights and measures are understood at schools, I may refer to the statement contained in many arithmetic books (even in those of Dr. Colenso and Mr. Barnard Smith), that the standard yard is determined by the *length of a pendulum vibrating seconds*, and that the standard pound is the *troy pound of* 1758, in the custody of the Clerk of the House of Commons. More than 30 years since the researches of scientific men threw doubts on the accuracy of such a method of restoring the standard of length; and in 1853 an Act (18 & 19 Vict. c. 72) was passed, reciting that in event of the standardyard being lost, it may be restored by reference to one of the copies then authenticated; and that the standard pound is the avoirdupois pound, of 7,000 grains. The primary standard yard and pound are at present in the custody of the Warden of the Standards.

3. The metric system of weights and measures.

"3. The metric system of weights and measures is now universally adopted by scientific men, its use greatly facilitating the exchange of scientific experience. Full description and tables of the metric system of weights and measures may be found in good arithmetic books; but its teaching in our public schools is at present limited, under the instruction of the Council of Education, to hanging a chart of the metric system on the walls, from which they are to learn the principles of the metric system and be able to explain the advantages to be gained from uniformity in the method of forming multiples and submultiples of the unit.

"The advantages of the metric system of weights and measures in education has been shown by J. Yates, Esq., F.R.S., in a lecture before the United Association of Schoolmasters.* Attention has been called to these alleged advantages in a paper by the Warden of the Standards, appended to the Second Report of the Standards Commission, p. 116, in the following terms:—'Great stress is laid by the 'International Association† and by the advocates 'of the metric system on the saving of time in 'education which would result from its general 'adoption. The following is an extract from the 'memorial to the Chancellor of the Exchequer from 'the International Association, presented 19th March '1859 (p. 21):

"'VII. Another most important consideration is the saving of time in education. Those who are employed in training boys for commercial pursuits bear an unanimous testimony to the irksome labour of teaching the tables of weights and measures, and the system of arithmetic long established in this country; and they declare that the introduction of the metric system would be equivalent to the saving at least a year to them and their pupils. This year is generally lost because the weights and measures are for the most part forgotten as soon as learnt.

"'In truth it is to the advantages possessed by the metric system, in its application of an uniform decimal scale of weights and measures and coins by which any amount can be expressed under a single denomination, that the looked for results are wholly attributable.'

4. New tables of necessary weights and measures appended.

"4. These few remarks may serve to explain the necessity for more simple and accurate teaching of weights and measures in schools, and for this purpose I beg leave to submit to the Commission tables of weights and measures not only to be learnt by memory, but to be understood by a systematic course of object lessons.

"Only the troy *ounce* has been placed in the tables, for troy weight is no longer in general use, and the troy ounce alone is generally used by those engaged in gold and silver dealings. All the most important assay reports and 'standardizing' tables of the present time, such as those of the Bank of England, are made on the millesimal system of reporting, so that there is no necessity to perpetuate a table of troy weights. The Standards Commission in their Third Report have also recommended the abolition of troy weight.

H. J. CHANEY.

"Standards Office, 28th May 1872.

A LIST OF WEIGHTS and MEASURES necessary to be learnt in Schools, Charts of which should be hung on the walls.

AVOIRDUPOIS WEIGHT.

16 drams = 1 ounce (oz.).
16 ounces = 1 pound, or 7,000 grains.
14 pounds = 1 stone.
8 stones = 1 hundredweight (cwt.).
20 hundredweights = 1 ton.

TROY WEIGHT.

(For Gold and Silver.)
1 ounce troy = 480 avoirdupois grains.

METRIC WEIGHT.

1 kilogramme (kilog.) = 2·2 or $2\frac{2}{10}$ avoirdupois pounds.
1 hectogramme = 0·1 kilog.
1 dekagramme = 0·01 „
1 gramme = 15·4 grains.
1 deci-gramme = 0·1 gramme.
1 centi-gramme = 0·01 „
1 milli-gramme = 0·001 „

LINEAR MEASURE.

12 inches = 1 foot.
3 feet = 1 yard.
5½ yards = 1 pole.
40 poles = 1 furlong.
8 furlongs = 1 mile.

METRIC LINEAR MEASURE.

1 metre = 39·39 inches.
1 decimetre = 0·1 metre.
1 centimetre = 0·01 „
1 millimetre = 0·001 „

MEASURES OF SURFACE.

144 square inches = 1 square foot.
9 „ feet = 1 „ yard.
4,840 „ yards = 1 acre.

MEASURES OF SOLIDITY

1,728 cubic inches = 1 cubic foot.
27 „ feet = 1 „ yard.

---

[*] Improvements in Arithmetic, Bell and Daldy, 1860.

[†] International Association for obtaining an uniform decimal system of weights, measures, and coins.

H. W. Chisholm, Esq.

7 June 1872.

MEASURES OF CAPACITY.

4 gills = 1 pint.
2 pints = 1 quart.
4 quarts = 1 gallon.
2 gallons = 1 peck.
8 ,, = 1 bushel.

METRIC MEASURES OF CAPACITY AND SOLIDITY.

1 litre = 0·22 or $\frac{22}{100}$ gallon.
1 litre = contents of a cubic decimetre.

"Models of the following series of weights and measures should be placed before each student, with the means for comparing them:—

AVOIRDUPOIS WEIGHTS.

"The following series used in shops, &c.;
56, 28, 14, 7, 4, 2, 1, pounds.
8, 4, 2, and 1, ounces.
8, 4, 2, 1, and ½ drams.

METRIC WEIGHTS.

10, 5, 2, 1, kilogrammes.
10, 5, 2, 1, hectogrammes.
10, 5, 2, 1, dekagrammes.
10, 5, 2, 1, grammes.

LINEAR MEASURE.

A yard divided into feet and inches.
Also a metre divided into decimetres, centimetres, and millimetres.

MEASURES OF CAPACITY.

"The following denominations used in shops;
Bushel. Gallon. Pint.
Peck. Quart. Gill.

"The following denominations used in scientific investigation—
1 litre, or 1,000 cubic centimetres (c.c.).
500 c.c.
200 c.c.
100 c.c.
5 c.c.
2 c.c.
1 c.c.

MEASURES OF SURFACE AND SOLIDITY.

"A model, one yard square divided into square feet and inches.

"A model to represent the size of the cubic foot, having the weight of a cubic foot of water marked on it, (62·321 lbs.)

"A model to represent the measure of a cubic decimetre, having 'measure of cubic decimetre = 1 kilogramme weight of distilled water' marked on it, and with one side divided into square centimetres, and 1 square centimetre divided into square millimetres.

"The student should be accustomed to work problems in weighing and measuring by these models, and not by the tables."

I may state generally that the paper endeavours to show, first, the efforts made by men of science for the establishment of scientifically accurate standards of weight and measure; secondly, the practical necessity of standards based on scientific principles for the advancement of science; thirdly, the neglect of the Government as to the application of science to the construction and use of accurate standards; fourthly, the present condition of the Standards Department in regard to its scientific duties; and, fifthly, the expediency of the permanent establishment of a scientific body in connection with the Government, and recognised by Parliament, as affording a better security for the application of science to Government work when scientific aid and counsel are needed, and thus to the advancement of science on national purposes.

11,657. Will you be so good as to state generally what are the scientific duties of the Standards Department?—The scientific duties of the department may be classed as follows: As to under general heads; first, the study of the scientific construction of standards as to their materials and mode of construction; secondly, the study of instruments for comparing standards; thirdly, the study of the dilatation and contraction from heat of metals and other materials used in connection with standards; fourthly, minute observations of temperature as indicated by thermometers; fifthly, the study of effects of atmospheric and other influences upon standards, and comparisons of standards; sixthly, the study of methods of comparing standards; seventhly, mathematical computations of results of comparisons of standards and their probable errors. And with regard to measures of length, microscopical observations, including the support and illumination of objects and micrometrical measurement. As to weighing, first, the study and manipulations of balances, including the vacuum balance and the use of the air-pump; secondly, observations of the barometer, as well as of the thermometer; thirdly, the study of the density of standard weights; fourthly, the study and observation of atmospheric air, its density, moisture, impurities, expansion, &c.; fifthly, similar study and observation of water and its distillation. As to measures of capacity and volume, the study and observation of the composition, hygrometric condition, expansion, pressure, motion, &c., of air and gases. And, generally, as required by section 11 of the Standards Act "to conduct "all such comparisons, verifications, and other operations, with reference to standards of length, weight, "or capacity, in aid of scientific researches" as may be required. To these may be added, the duties relating to the preparation of new standard trial plates for coins under the Coinage Act, 1870.

11,658. Will you proceed to state what is at present the exact status of the department under the Board of Trade?—The exact status at present is merely a provisional one. Although, under the Standards Act of 1866, a substantive department in connection with the Board of Trade and subordinate to it was to be established, there has in fact been no establishment yet of the department. Notwithstanding that a Royal Commission sat upon the subject and made many important recommendations two years since, nothing whatever has been done to carry out these recommendations. Originally the department was placed under the commercial department of the Board of Trade. That was abolished on the 31st of March last, and now the Standards Department, such as it is, is placed under the Harbour Department of the Board of Trade. In fact, so far as relates to its constitution, the department is much in the same state as it was in the old Exchequer, of which the Scientific Committee of 1864 complained so very much that it was looked upon as a mere subordinate and apparently unimportant appendage to one of the great departments of the State, and that it was absolutely necessary for the creditable course of the office that it should be delivered from such a position. In that respect at present the Standards Act certainly has not been carried out, nor have the recommendations of the several Commissions that have been made upon the subject.

11,659. Are we to understand that the Act provides that a permanent department should be created?—Certainly. The provisions are contained in the 10th section of the Standards Act of 1866. The previous clauses define the standards and some of the duties relating to the standards, and the 10th clause goes on to say, "For the purposes of this Act, the Board of "Trade shall constitute a department of their office "to be called the Standard Weights and Measures "Department of the Board of Trade, and shall appoint as head of that department an officer to be "styled the Warden of the Standards, and shall "appoint and employ so many clerks and subordinate "officers, and at such salaries as the Commissioners of "Her Majesty's Treasury from time to time approve."

11,660. In what respect does the present condition of things differ from what is intended in the Act of Parliament?—That no Standards Department yet is

H. W. Chisholm, Esq.

7 June 1872.

formally constituted, and there is not an appointment of a single officer to the Standards Department.

11,661. They have only been appointed provisionally?—Simply provisionally, as officers of the Board of Trade. It was necessary, as soon as ever the Act was passed, for the Board of Trade to take some action to enable the work of the department to be carried on, and for that purpose a minute was drawn up merely constituting myself and Mr. Chaney officers of the Board of Trade, but nothing further whatever has been done in that respect. The correspondence on the subject was laid before Parliament in 1867, in a Parliamentary paper of the Board of Trade, where it was stated that the appointments were simply provisional.

11,662. Has the subject, so far as you are aware, been under the consideration of the Board of Trade during the last two years?—I am not aware that it has, although I have several times drawn the attention of the Board of Trade to the existing unsatisfactory state of things, and particularly to the recommendations of the Standards Commission; but all that has been done, in answer to that, was a minute of the Board of Trade to say that nothing could be done with regard to the department until an Act was passed to carry out the recommendations of the Standards Commission.

11,663. Is it considered by the Board of Trade that an additional Act of Parliament is required?—It would appear so; the Standards Commission have recommended very large and important alterations in the system of weights and measures throughout the country, giving very great additional power to the Standards Department and to the Board of Trade over the local officers and the execution of their duties. At present there is no control whatever on the part of the Government over the local officers. They are subordinate to the respective local authorities, and the consequence is that there is no general code of regulations for the uniform and regular performance of their duties, and each man does what he thinks right to carry out the Act, the result being that the law is differently carried out in different parts of the country. There is no security for its being properly carried out, and the complaints are general upon the subject. In order to remedy this state of things, the Standards Commission made very large recommendations, and they also recommended that the present laws relating to weights and measures should be consolidated in one general Act, so that it is a very large subject to go into. In point of fact, as it is to be undertaken by the Government, and they have since been much pressed by other matters, the Government really have as yet been able to do nothing so far as regards the passing of an Act, through Parliament, to carry out the recommendations of the Commission.

11,664. The conversion of the present provisional condition of the department into a permanent one would be of comparatively little importance, unless an additional Act of Parliament were passed giving greater powers to the Standards Department?—I believe the truth is that they do not care to go into the matter now; they are waiting until they can deal with the whole subject at once. The Board of Trade have so many things pressing upon them, they have so many different objects, and so many different departments of the Board of Trade, that it is more than they can do to get through all their other work at the present time. There is, however, a great deal of work now done in the Standards Office, and so far as regards the standards, and the scientific duties of the Department, no further legislative authority is required. In these respects the provisions of the Standards Act of 1866 have been and are now in full practical operation by the provisional officers, by whom also all the preparatory work for establishing an improved system of weights and measures throughout the country has been done; and a very arduous and responsible work it is. I cannot therefore but feel that it is not just to the officers who do the work that they should be so long left in their present provisional position, nor is it creditable to the Board of Trade that they should so wholly disregard the recommendations made in regard to this point by the Standards Commission, in the Postscript to their Fifth Report, and should continue to leave unfulfilled the direct provisions of the Standards Act of 1866.

11,665. Is there special scientific authority in the Board of Trade to which the Standards Department is subordinate?—I am not aware that there is any whatever. They leave all those scientific questions entirely to me. They do not enter into them in any way.

11,666. Is there any scientific authority to which you can appeal in case of need?—There is no scientific authority to which I am entitled to appeal. It happens, at the present time, that I have the advantage of appealing to my former colleagues in the Standards Commission, to the Astronomer Royal and to Professor Miller, and I get a great deal of assistance from them in that way, especially from Professor Miller. In fact I could hardly have executed the scientific duties of my department without having assistance of that kind, but such aid has been obtained merely in consequence of my relations with them as a colleague. I am in nowise authorised to call upon them or upon any other scientific authority for information or assistance. I may here particularly refer to one subject which is mentioned in my paper, the preparation of new standard trial plates for coin. I actually required scientific information upon that point, and I could only apply to the Astronomer Royal, but his time was taken up so much that after some time he declined interfering in the matter, so that I have been obliged to act in the matter without having any scientific authority to aid me, although it is a very responsible duty cast upon me by law.

11,667. The Act of Parliament to which you refer makes no provision for any scientific authority to superintend the duties of your department?—None whatever.

11,668. I observe that a Commission has been in existence and has been revived from time to time to give its aid in various matters connected with your department?—Yes, that was found to be absolutely necessary. The Commission was first formed after the destruction of the legal standards by the burning down of the Houses of Parliament. It was necessary to take steps to construct new standards, and for that purpose Lord Monteagle, then Mr. Spring Rice, who was the Secretary of the Treasury, and, as a member of the University of Cambridge and a member of the Royal Society, was personally acquainted with many scientific men, asked some of them to assist the Government in restoring the standards. That was the origin of the Standards Commission, of which the Astromomer Royal, one of the most eminent members, was the chairman. They were appointed in 1838, and they reported in 1841, and they stated the steps which they considered to be necessary for the construction of new standards. They were not contented with that; they wished to point out how those standards might be made most useful both for scientific and for commercial purposes, and they made a great number of important recommendations. I have their report with me (*producing the same*), and appended to that report are a great number of recommendations under different heads. They were re-appointed as a Commission in 1842 to carry out those recommendations, and to construct new standards, and they were employed from 1842 to 1854 in the construction of those new standards, and some of the most eminent scientific men who had given their attention to the subject were upon that Commission. One of whom was Mr. Baily, who was a great authority upon standards. He had written a paper upon the subject in the Transactions of the Astronomical Society, and it was left to him to superintend the construction of the measure of length. He died after a short time, and the work then fell into the hands of Mr. Sheepshanks, and an immense number

H. W. Chisholm, Esq.

7 June 1872.

of observations, no less than 200,000, were made by Mr. Sheepshanks himself with the microscope, and are referred to the account of the construction of the standard of length which was laid before the Royal Society. The operations with regard to the standard of weight, the new standard pound, were left to Professor Miller and carried through entirely by him. His time was taken up for a good many years, and he made an immense number of observations which are detailed in the account given by him. The result of the labours of the Commission was, that at the end of 12 years the new primary standards were completed, and 40 or 50 copies of both the standard yard and the standard pound were constructed, being all made with the same scientific accuracy as the primary standards, and were deposited in different places in this country, and abroad. In 1864 the services of the Commission were again called into request under the following circumstances. The primary standards by law were lodged in the Exchequer. They were placed in three separate boxes, one within the other, and besides that they were deposited in a stone coffin in the strong room to be perfectly secure. They might as well have been dead and buried at once for any good that they did there, after all the scientific labours for their construction; for there they lay for 12 years, and there was not the slightest attempt made to do anything with them, or to correct our working standards by them. In fact, there was no machinery in the office by which we could deal with them in any way. We had no scientific instruments, we had no scientific knowledge of any kind in the office. The weights and measures department of the Exchequer then consisted of two clerks without any scientific qualifications, and that was the state of things when I was appointed chief clerk of the Exchequer in 1862. Before that I had nothing to do with the weights and measures; I was head of the Exchequer Bill Department. However, very soon afterwards my attention was directed to the subject in consequence of the weights and measures of the country being more noticed in Parliament, and at different times many questions being asked, first of the Secretary of the Home Department, next the Secretary of the Treasury, and next the President of the Board of Trade, who sent down to the Exchequer to get information to enable them to answer the questions put to them. As chief clerk, it happened that the duty was thrown upon me of supplying this information as well as I could. Under these circumstances, I told Lord Monteagle that it was absolutely necessary for me to make myself thoroughly acquainted with the subject, and the result was that I drew up a long paper which was printed and laid before Parliament, a copy of which I have already laid before the Commission. I next obtained permission from Lord Monteagle to inspect the condition of the standards, as I was apprehensive of their being injured from the damp state of the room in which they were kept. I may mention that previously to this time the Exchequer office had been removed from Whitehall Yard to Old Palace Yard, when the box containing the standard had been taken from the stone coffin and deposited in the large iron chest in the strong room of the new office. The boxes were accordingly taken out of the iron chest, but we were about two hours before we could get at the standards, the screws being all rusted in, and we were obliged eventually to burst open the boxes. When we came to the standard yard, we were glad to find that it was perfectly uninjured, as it was made of very good metal, and the damp had had no effect upon it. The next thing was to look at the standard pound; and when we opened the box, we found one mass of foul fungus, and could see nothing whatever of the standard. We feared that it was ruined. After consultation with the Treasury, it was agreed that the only thing that could be done was to revive the Standards Commission, and place the matter in their hands. That was done in 1864, and the manipulation of the fungus upon the standard was left to one of the members of the Commission, the late Mr. Graham, then Master of the Mint; and after some time, by the application of powerful agents, he managed to clean it, and he found, fortunately, that the platinum of which it was composed, was perfectly uninjured. The standard pound was subsequently compared with other standards by Professor Miller, and the Commission made their report that it was wholly uninjured.

11,669. (*Dr. Sharpey.*) Was not it compared with the Royal Society's standard?—It was compared with the four parliamentary copies of the standard. There are four principal copies of the national standards, one copy is lodged with the Astronomer-Royal, one with the Royal Society, one with the Master of the Mint, and one is built up in the wall of the House of Commons, and it was considered necessary to unwall these parliamentary standards from the House of Commons. That was part of the duties of the revived Commission, who took steps to examine those standards; but, however, there was no damp there, it was a dry wall, and they were found to be perfectly uninjured, and so they were replaced there. But the Commission were not satisfied with reporting upon the state of the standards; they also again called attention to the discreditable state of the office itself, and the necessity of establishing a Standards Department. They made some very strong representations upon the subject, but it was not until it became absolutely necessary to take some steps for dealing with the standards, on the occasion of the new arrangements of the Exchequer in 1866, that the attention of the Government at last was drawn to the subject. It happened that I was one of a committee appointed by the Treasury to make all the detailed arrangements for dealing with the duties of the Exchequer, and eventually a Treasury minute was passed, which I had drawn up under the directions of the Treasury authorities, in order to carry out the recommendations of the several commissions and committees for establishing a Standards Department, subordinate to the Board of Trade, and an Act of Parliament was also passed for the same purpose. At the same time the Government agreed to appoint another Royal Commission to consider the whole subject. That Commission was appointed in 1868, and was principally composed of such of the members of the Standards Commission as were still alive. They sat from 1868 to 1870, and made five Reports upon the whole subject of the standards and their use throughout the country, which are contained, together with the appended papers, in the volumes which I now beg leave to lay before the Commission (*delivering in the same*).

11,670. (*Chairman.*) That Commission is, I believe, no longer in existence?—That Commission has come to an end. It was a question how far it could properly be considered as a temporary Commission, because the duties assigned to it were such as would recur at a future time, and from time to time; but according to the terms of the Commission, it was agreed that it was a temporary Commission, and that they must conform to the rule that when the objects for which a Commission has been appointed have been accomplished, then the Commission dies a natural death. Therefore, after completing their fifth report the Commission came to a close in 1870.

11,671. There is no Committee or Commission authorised periodically to examine your department at present?—There is not, although it was particularly pointed out by Lord Monteagle that it would be necessary that the scientific duties of the department, more particularly the scientific re-verification of the standards, should take place under high scientific supervision, but there are no means provided at the present time for carrying out that recommendation.

11,672. Do you think that Lord Monteagle's recommendation is one of great importance, and that there should be some periodical scientific supervision of the state of the department?—I am quite sure that it is absolutely necessary for the proper conduct of the

H. W. Chisholm, Esq.

7 June 1872.

business of the office that there should be some scientific authority to which they can appeal, and which shall add weight to the operations of the department. For instance, supposing, as most probable, in the course of time, that a bill should be passed to carry out the recommendations of the Standards Commission with regard to the improvement of the system of the verification and inspection of weights and measures throughout the country, in that case it will be necessary to draw up a code of regulations and instructions, not only for the guidance of the local officers in the performance of their duties, but also for the construction of all weights and measures and balances and instruments of that kind.

11,673. (*Dr. Sharpey.*) You mean generally all the legal weights and measures used throughout the country?—Yes, all weights and measures authorized to be used throughout the country; and more particularly, as it is proposed to have two systems legally in operation, the metric system and the imperial system, means must be devised as far as possible to prevent any confusion arising between the use of weights and measures of the two different systems. For the attainment of these objects in a way satisfactory to the country, I think the aid and support of an authoritative body of scientific men will be required. That has been done in France, and that has been done and is now being done in Germany. In each country they have a Commission of scientific men to consider many points relating to science that occur in the construction of weights and measures and in their mode of verification. And I consider that something of that kind will be absolutely necessary in this country. Again, there are other scientific operations of the Department to which I may call the attention of the Commission, and one in particular, which is in contemplation at the present time, namely, the redetermination of the weight of a cubic inch of water. The necessary instruments are now being prepared for this object, but the process will be one of a very laborious and difficult nature, and one in which scientific aid will be very desirable.

11,674. Would the duties of such a scientific authority be onerous, would the members of it have to give up a large portion of their time to the duties?—I should think not. It would probably act rather by way of advice and counsel upon difficult points, as well as giving authoritative support to the department in carrying out its scientific duties. The actual manipulation and conduct of the operations might be left to the officers of the department, in the same way that, whilst the members of the late Standards Commission had very little actual work to do, the preparation and practical execution of all the business brought under the consideration of the Commission fell upon me, or were done under my directions. The course pursued with regard to any of the scientific duties of the department was first to bring the matter under the consideration of the Commission as to the mode in which it should be done, and then from time to time to refer to them anything that required their sanction or counsel, and when the work was completed to report the whole of the proceedings to them and get their sanction to the results.

11,675. (*Professor Stokes.*) Are you speaking of the last Standards Commission?—Yes.

11,676. Because the Commission that was appointed for the restoration, did a great deal of work; did they not?—Yes, in that Commission the whole of the work was done by themselves. At that period, neither the equipments of the Weights and Measures Department of the Exchequer, nor the qualifications of the two clerks employed in it, were such as to enable the Commission to derive any assistance whatever from them in the execution of the work of restoring the Standards. It was upon this very ground that the Commission so strongly urged the necessity of establishing a substantive Standards Department, with a competent and responsible chief officer.

11,677. (*Dr. Sharpey.*) And do you think that such a Commission as that to which you are now referring would be required to be a standing and permanent Commission, and that there would be constant work for them for an indefinite time; or whether, when that particular work which you are now mentioning was carried out, it would be needful to continue such a Commission?—So far as regards the work of the Standards Department, the assistance of any scientific council or Commission would be required merely from time to time, certainly not continuously, and it would take up comparatively but little of their time; still there might be occasions when their time and attention might be occupied for a longer period, but I do not anticipate that that would often be the case.

11,678. (*Professor Stokes.*) Do you consider that there is at present a sufficient guarantee that the present and future officers of the Standards Department have the requisite scientific qualifications?—We have more guarantee now through the Civil Service Commissioners than we had before. They have the means of ascertaining any scientific qualifications that may be required upon the subject being specifically referred to them, but it rests entirely with the President of the Board of Trade, who has the appointment of any officers, whether they have any scientific qualifications or not. He has the sole responsibility of appointing a properly qualified person to the office.

11,679. (*Dr. Sharpey.*) How do the Civil Service Commissioners determine the fitness; is it simply by a written examination or is there any practical work?—They always examine candidates in the subjects that are indicated to them by the head of the Department in which the appointment is made. The head of the Department states what qualifications are required, and in what subjects the person is to be examined. Then the Civil Service Commissioners take care to get the best scientific assistance they can, and it is left entirely to them to conduct the examination as they think right.

11,680. Is the examination at all a practical examination? Are the candidates tried practically?—They are tried both theoretically and practically, according as they are requested. For instance, when Mr. Chaney, my first assistant, was appointed, it was considered desirable to have a young man who knew something about the manipulation of standards, particularly of gas measuring standards, and some pains were taken by the Treasury to get a properly-qualified man, and he was examined specifically in natural philosophy by Captain Galton, to see that he had the proper qualifications.

11,681. Had he to do any experiments, or any practical exercises in the way of measurement or observation?—No.

11,682. It was entirely on paper?—Yes, the examination was entirely on paper. There were no models or instruments at all employed.

11,683. (*Chairman.*) Do you think that any further guarantees are desirable to secure the appointment of proper officers?—I think that, at the present time, we have sufficient security in the responsibility of the minister who appoints, and the machinery of the Civil Service Commission.

11,684. (*Dr. Sharpey.*) Are the new officers appointed provisionally and under probation?—It is generally the custom in the Civil Service now to appoint every officer provisionally, to nominate him, as it is called, and at the end of six months the head of the department has to make a special report as to his competency, and then the practice is for the Board of Trade to confirm his appointment, and that rule extends to the lowest messenger.

11,685. (*Chairman.*) Have you any further evidence as to the stated "apathy of the Government" in relation to the standards?—I think I may refer upon that point to the letter of the Astronomer Royal, dated the 1st of February 1859, on the subject of the standards, already mentioned in my paper. He divides his letter under several heads, and the third head is, "On the "presumed error in the general theory of British "legislation on the subject of standards, and the "mode of correcting it." Upon that he says, "The

H. W. Chisholm, Esq.

7 June 1872.

"entire spirit of our legislation on the subject of furnishing the community with accurate standards may, I conceive, be correctly described in these terms. They are granted to municipalities and provinces merely as expensive indulgences. The Government will take no part either in furnishing the standards or in compelling the local bodies to furnish themselves, or in enforcing the continued maintenance of accuracy of the standards; but if the local bodies desire them they may have them, provided that they pay, in addition to the expense of purchase, the fees of comparison, and also a tax to the Government in the form of stamp duty upon an indenture." "The conclusion which any logical person must draw from this is, that the Government wishes to discourage the use of standards, but that they have made some concession to popular demands, availing themselves of the opportunity to raise some money for the purposes of the State. The conclusion as to the entire apathy of the Government is further supported by the consideration that the Government absolutely declines to interfere for the purpose of carrying out its own ostensible measures in all cases where a municipality, a guild, an university, or a court leet has heretofore possessed the privilege of doing so." He then makes several important recommendations for the improvement of that state of things, and he says, "I think, therefore, that the spirit of our legislation on standards ought to be entirely changed. It ought I think to be the duty of a department of the executive to undertake, as of its own authority (not as supplicated by others), that every part of the realm, descending to such subdivisions as may to the Executive appear convenient, should be furnished with such apparatus (whether inspectors' standards, mural standards, approved balances, or any other) as the Executive may judge fit for insuring accuracy in all transactions of measure or sale. And also that the same department should possess such authority over the persons employed on the part of the State in the official use of that apparatus as will enable it effectually to carry out the intentions of civilised government in the institution of standards." In his next head he goes to the presumed error in the practice of the British executive, and refers to the appointment of a proper and efficient Standards Department. I may also call the attention of the Commission to the remarks which follow: "The first important point is a selection of a chief of the Standards Department; and here I remark, that there is no need to take a person possessing the highest scientific or philosophical qualifications. The demands for comparisons of the greatest possible accuracy, though peremptory when they do arise, occur but seldom; and the legislature may well contemplate that in those rare instances the work may be executed under its own scientific officers (as the Master of the Mint, the Superintendent of the Ordnance Survey, the Astronomer Royal), or with the assistance of Fellows of the Royal Society (to which body the accuracy of the British primary standards is entirely due). The general qualifications required in the chief of the Standards Department are accurate and business-like habits, readiness to master the delicacies of the Standards comparisons," *&c.* That letter was addressed to Lord Monteagle, the Comptroller-General, who transmitted it to the Home Secretary with his entire concurrence, and at the same time he referred to the Recommendations of the Commissions of 1841 and 1848, and stated, "It is almost inconceivable that this important document" (that is the Report of 1841) "and the evidence subjoined to it should not for seventeen years have attracted the attention and notice of successive Governments and of the Legislature."

11,686. Will you explain the distinction between the scientific and the administrative duties of the Standards Department in relation to the Board of Trade?—As I have already referred to the scientific duties of the department, it may be sufficient to state that, although the administrative duties at present are of a limited extent, as we only undertake the verification of such of the local standards as the local authorities are pleased to send to us, yet they will become of considerable importance if the recommendations of the Standards Commission are carried out, as the department will have to exercise a direct control over the performance of the duties of all the local officers of verification and inspection of weights and measures throughout the country.

11,687. Does it frequently occur that weights and measures are sent to your department for verification?—That is continually being done. There is hardly any period when we have not some local standards in the office which have been sent to us for verification or reverification; that is the ordinary business of the department, involving much technical and clerical work, and a great deal of correspondence. It varies from time to time in amount. Sometimes we have a great press of work, and there are great complaints that we cannot get through the work more quickly, and at other times the work is more slack.

11,688. Are there no local officers whose duty it is to send in periodically the weights and measures for verification to your department?—That duty rests with the local authorities, or rather with their officers, the inspectors of weights and measures. The law says that if the weights are not verified at least every five years they are no longer legal, and that the measures must be verified every 10 years or else they are not legal. That is the only obligation upon these local authorities and officers with regard to this point, and the result is that if they do not send them within the time prescribed by law, they have no means of carrying out the weights and measures law, and of verifying weights and measures legally or of punishing offenders; but in spite of that, we find from time to time that there are a considerable number of districts of inspection where the standards are not duly reverified, and I show them up every year in my annual report to Parliament. My last annual Report for 1870–1 contains a list of 80 places in the United Kingdom where their standard weights were thus no longer legal, and of 58 places where their standard measures were no longer legal.

11,689. In those districts the weights and measures used are, I presume, no longer strictly speaking legal?—Strictly speaking, the commercial weights and measures in such districts cannot be called illegal, if they bear the stamp of the inspector; and even if actually incorrect in relation to the Imperial Standard, no legal means exist of proving them to be incorrect, in the absence of legal local standards. But in spite of that, I believe the actual fact to be that the verification and inspection of weights and measures goes on just the same, and there is nobody to call the local officers to account for their negligence. Even up to the present time, we have occasionally standards sent to us for reverification, which were originally verified in 1825, and never reverified since. These appear to have been continually used by the local inspectors, although they have become illegal since the passing of the Act in 1859, requiring their periodical reverification.

11,690. Does it frequently occur that when weights and measures are sent in to your department for verification they are found to be inaccurate?—We very seldom see the state in which the standards are when they are last used, as they are never sent direct to us. We do not undertake any responsibility as to the transport of the standards to and from the office, or their adjustment; and the practice is to send them to one of the manufacturers of standards in London, who adjusts them before they come to us, so that, generally speaking, they are correct, or very nearly correct, when they come to us. They may require some trifling adjustment, for there are certain limits of error tolerated in standards, and if the errors are not within those limits we send them back; that is occurring constantly, because we are very strict in

H. W. Chisholm, Esq.

7 June 1872.

our requirements. But I know, as a matter of fact, that in many cases the standards are allowed to get into a disgracefully dirty and defective state. I have happened to have seen them occasionally when I have been at the manufacturers.

11,691. But they are seldom sent into your office for verification whilst they are in this inaccurate condition?—They are never sent to us in that state.

11,692. They always take measures, do they, previously to get them tolerably correct?—They do, and they are obliged to do so before they come to us, by the requirements of the office.

11,693. Do you think that any new regulations are required. Would you recommend that they should be obliged to send them in to your department exactly in the condition in which they had been in constant use?—Most certainly considerable improvements are required in the system. The Standards Commission have gone into all these points very carefully, and have made many recommendations on the subject. One of the principal recommendations is that there should be supervisors, of verification subordinate to the Warden of the Standards and to the Board of Trade, who should travel round and see all the standards as they are actually used in the different districts of verification, to inspect their other instruments, and the mode in which they carry out their business. Such a practice of supervision would be absolutely necessary under the new system by which a code of regulations is proposed to be framed for the guidance and government of every local officer in the discharge of his duties, and there must evidently be some machinery to secure that those regulations are properly carried out.

11,694. That cannot be done, I presume, until the Act of which you have been speaking has been passed?—It cannot. That is part of the new system which we have recommended to be carried out by legislative enactment.

11,695. (*Sir J. P. Kay-Shuttleworth.*) Are there particular places for the deposit of local standards, as, for example, in boroughs, or are they defined by Act of Parliament?—That is left to each local authority. The local authorities for this purpose at present are the county magistrates for counties, and the corporations in all municipal boroughs and cities, under the Acts of 1824 and 1835; and by the old law, which is still in force, as well as under private and local Acts, the authorities of every parish are also the local authorities for this purpose. For instance, at the present time, in the parish of Saint Marylebone, in which I reside, the vestry is the local authority, and the stamper of weights and measures there is the beadle, I believe, and the inspection is carried on by the old system of annoyance juries, which is as old as the time of Henry III. Again, there are several manors where they have the right of having standards, and the jurisdiction of them rests with the courts leet. The Standards Commission have proposed to do away with all that complicated old system, and that the Government should have the power of defining who are to be the local authorities after the Act has been passed, which will itself define the local authority at the time of the passing of the Act.

11,696. Have you any conception as to the number of authorised places which do possess accurate standards?—At the present time there are nearly 1,400 districts of inspection of weights and measures in the United Kingdom. The inspectors now are also verifiers—there is but one system of verification and inspection. The Commission have recommended that they shall be distinct, as they are in other countries, and that the duties of verification shall be performed by properly qualified persons, and that the duties of inspection, which are rather of a police nature, shall be executed by a distinct class of inspectors, who will generally be policemen.

11,697. Of those 1,400 places, have you any conception how many possess accurate standards?—Every district has been furnished with accurate standards, which have been verified at the Exchequer, except in Ireland. There is a different system in Ireland from that which exists in England. By the Irish weights and measures law the local inspectors, who are all officers of the constabulary, have sub-standards made of iron, which are always re-verified locally. In each principal district there are copies of our standards verified by us, and they themselves verify their working standards of iron in the 600 or 700 subdistricts of inspection in Ireland, from the standards verified in the Standards Dedartment. There are upwards of 700 districts of inspection in Great Britain, including the divisions of counties, together with cities, towns, parishes, manors, and liberties.

11,698. (*Sir J. Lubbock.*) Do you include any manors or liberties in the 1,400?—Yes, for instance, the liberty of the Tower is one.

11,699. (*Chairman.*) By whom are the duties of those bodies, in relation to weights and measures, discharged?—The duties of verification and inspection are discharged by the inspectors of weights and measures appointed by those bodies, and the adjudication of cases of offences against the weights and measures laws rests with the local magisterial authorities.

11,700. (*Sir J. Lubbock.*) Does the office exercise no authority in those special jurisdictions?—None whatever; and I would also point out that there are a great number of markets and fairs all over the country which are generally established by local Acts, and it is a common practice to get a clause inserted in the local Act empowering the proprietors to regulate all the weights and measures in the fair or market. The consequence is that no inspector of weights and measures dares to go into a fair or market to inspect their weights and measures, and there is practically no inspection whatever in them at the present time.

11,701. (*Chairman.*) Do you think it desirable that the number of districts should be greatly reduced?—Yes, they should be very much reduced, and fit persons appointed who should be properly paid. Four-fifths of the men who now exercise the duties of inspectors of weights and measures are paid nothing whatever for their labour.

11,702. Is not some allowance made in most counties to the police for the duties that they discharge?—In very few cases are the police paid anything whatever, beyond the actual expenses to which they are put; the inspection of weights and measures is an additional duty thrown upon them, and they have to do their own duties of police at the same time.

11,703. Has any private individual, if he thinks fit, a right to come to your office and ask to have his weights or measures verified?—At present we do not verify for any private individual. The old rule has been that, whenever we verified any copies of our standards, we delivered them to a particular person or officer authorized to receive them, thus creating a trust, and it has always been customary to draw up a legal indenture in two parts, one of which accompanies the verified weights and measures as a certificate of verification, and the other we keep in the department so that we can communicate, if necessary, with the person who has the custody of those verified weights and measures. The Standards Commission have recommended that we shall verify for all comers. A proposition to that effect was made by me to the Commission, as I thought that the Standards Department ought to be made as useful as possible to the public; and that was made part of our recommendations. But it would never do for us to verify for all comers without charging a fee, or else we should get over-done with work, and the local officers would have very little to do, and very little receipt to meet their expenses, so that it will be necessary, in such an event, to charge a certain fee according to the precision of the verification. The old practice was to charge a fee for verifying all the local standards. That was very much complained of by the Standards Commission in the Reports of 1841 and 1854, and it also acted as a preventive to the standards being duly sent

H. W. Chisholm, Esq.

7 June 1872.

for re-verification, and with some difficulty I got the Government to consent to give up these charges. We used to charge 3*l*. 8*s*. as the Exchequer fee for verifying a complete set of weights and measures, in addition to 3*l*. 10*s*. for the stamp duty on the indenture. By the Standards Act of 1867, all fees for verification, and stamp duty on the indenture, were directed to be discontinued. The consequence of that is that we cannot now charge any fee for verification without having the sanction of Parliament; and we are waiting till the recommendations of the Standards Commission are carried out, one being that we should be entitled to charge a fee for verification before we commence any verifications for private persons. We verify now only for the local officers of weights and measures, for a Government Department, or for any foreign Government. For instance, I recently verified some metric weights for the Peruvian Government.

11,704. Under what circumstances was the first-stated scientific verification of standards made?—I happened to come, a short time ago, upon the actual certificate of verification of the standard coal bushel of 1730, and I thought that it might be interesting to submit it to the Commission. There is the original certificate of verification bearing the signatures of three eminent scientific men; and there is the warrant of the Lords of the Treasury accompanying it, constituting, under an Act of Parliament, the new standard coal bushel a legal standard (*delivering in the same*). I may also refer, upon that subject, to the original verification of the metric standards at Paris. I have here a photograph of the original verification with the signatures of all the eminent men of science who composed the French Commission at the close of the last century, La Place being at the head of them (*delivering in the same*). The primary metric standards of Paris were constructed under an eminently scientific Commission there, not only from France, but from other countries, and the verification of them was signed by the following members: La Place, ex-president of the Institute; Lefevre-Geneau, president of the Institute; Antoine Monger, the secretary of the Institute; D'Arcét, La Grange, Méchain, Le Gendre, Delambre, Brisson, and Garran Coulon, all members of the Institute; and by the following scientific men who were delegates from other countries: Jobbroni, delegate from Tuscany; Van Swinden and Æneae, delegates from the Batavian Republic; Mascheroni, delegate from the Cisalpine Republic; Vassali, delegate from the Provisional Government of Piedmont; Multedo, delegate from the Ligurian Republic; Pedrayes and Ciscar, delegates from Spain; and Tralles, delegate from the Helvetian Republic; and also by two celebrated mechanicians of Paris, Lenoir and Fortin.

11,705. Who were the scientific men consulted in 1859 as to the construction of the gas measuring standards?—The Sale of Gas Act, 1859, was passed through the efforts of some persons who complained very much of the inaccurate state of the gas meters used for the measurement of gas. They conceived that it was a system which wanted very much improving; and the Gas Act passed through Parliament, and directed that gas-measuring standards should be constructed, and copies furnished for the use of inspectors of gas meters, to be appointed for verifying all the gas meters in use throughout the country. That Act imposed upon the Treasury the duty of constructing new gas measuring standards, to be deposited at the Exchequer for the purpose of verifying copies for the use of the inspectors. It was passed without the Government taking any part whatever in the matter, and when it was passed, the duty was thrown upon the Treasury of carrying out the Act, and they communicated on the subject with Lord Monteagle, the Comptroller of the Exchequer. But neither Lord Monteagle nor the Treasury knew anything about gas measuring standards or how they were to be constructed; and they were obliged to seek for further aid to enable them to carry out the provisions of the Act. Under those circumstances, Lord Monteagle did, in 1859, as he had done in 1835, he consulted his own personal scientific friends. I have placed before the Commission a copy of a paper relating to the proceedings taken for the purpose of carrying out the Sale of Gas Act, laid before Parliament in 1860; and in the correspondence there they will find the letters which were written by Lord Monteagle to the following scientific men:—Professor Wheatsone, George Lowe, and Dr. Frankland. Eventually, the Treasury begged the Astronomer Royal to undertake the direction of the matter. He had a great deal of difficulty in carrying out the Act, and in constructing the gas measuring standards; and eventually they were accurately and scientifically verified by him and Professor Miller.

11,706. Are the provisions of the Act generally observed throughout the country?—The provisions of the Act are observed very well in London, but very badly all through the country. The Act made it compulsory on every county to adopt the Act, but the county magistrates did not like it at all. They said that it would impose upon them a great deal of trouble, and a great deal of expense, all for the benefit of the towns where gas was used, and by whom the adoption of the Act was made permissive, and they thought that it ought to be left to the towns to carry out the provisions of the Act. In consequence of their representations to the Government, an amending Act was passed the next Session, and it was made permissive and not compulsory upon the counties to adopt the Act. The result is that at the present time there are only two counties throughout the kingdom that have adopted the Act. It has been adopted in a good many towns, but it is very imperfectly carried out throughout the country, except in the metropolis. In London the inspection of gas meters is more efficiently performed, because it is placed under the Metropolitan Board of Works, who have got duly qualified men, and proper office equipments for the discharge of the duties.

11,707. (*Sir J. P. Kay-Shuttleworth.*) Have you any recommendations to make as to the mode by which the uniformity of standards of measure and weight could be best practically introduced throughout the country?—We have made a great number of recommendations to that effect in the fourth report of the Standards Commission. The principal points are, first, that we should have properly qualified men to undertake the duties connected with the standards, and that the Board of Trade should have a *veto* as to the appointment and as to the amount of salary which they shall receive; because we think that they ought to be properly paid, or else you will not get properly qualified men. At the same time they should be examined by the Civil Service Commissioners as to their capabilities. If you get properly qualified men and make it worth their while to undertake the duties, and if, at the same time, you have a code of well considered uniform regulations to be adopted throughout the country, with respect not only to the verification and inspection of weights and measures, but also their construction, as well as that of balances and other weighing machines, and if you have a proper supervision to see that all the regulations are duly carried out, I do not see how you can adopt better means of having accurate standards than by carrying out the recommendations for these objects.

11,708. For a proper understanding of such standards, supposing uniformity were practically introduced throughout the country, would it not be necessary that some instruction should be given in them in elementary schools, as to the relation of such standards to customary local weights and measures?—I think that very desirable, and with that view I have placed before the Commission a paper by Mr. Chaney, my assistant, who has given great attention to the subject, and I think that the views which he puts forward in that paper are very well worth the consideration of the Commission.

11,709. In that point of view the elementary schools would become almost indispensable for the introduction

H. W. Chisholm, Esq.

7 June 1872.

of uniformity of weights and measures?—It would, I think, tend very much to the establishment of uniformity in weights and measures used for business transactions throughout the country if the public generally were better educated as to the legal denominations of weights and measures for which accurate standards are provided, and if their eyes were accustomed to their form and size, as well as their actual relation to each other.

11,710. Taking into account the present state of intelligence and information amongst the agricultural classes, the exceeding variety of the weights and measures which are adopted in different counties, and sometimes in limited districts, and the obscurity of the ideas of those classes of persons as to the relations of one local weight or measure to another, would it not be almost indispensable that the elementary school should give the basis of the information by which this reform should be introduced?—I am quite of the opinion that such elementary teaching is calculated to afford the readiest means of more general acquaintance with the units which form the basis of our system of weights and measures, and to tend to their uniform adoption. At the same time I should observe that there is a great deal of misapprehension of the diversity of weights and measures throughout the country. There is no diversity as regards the weights and measures themselves. You have but one yard, one foot, one gallon, one pound.

11,711. How many bushels?—You have only one bushel. I think I may challenge the Commission to produce in any part of the country any other bushel than the imperial bushel.

11,712. Do you mean that in the ordinary operations of agriculturists the bushels of different parts of the country correspond?—If they actually use the bushel measure, it can only be the imperial bushel according to the standard. They may use a sack of so many bushels, but there is no legal measure or standard of a sack. If you want to have a sack of three bushels, you must have a bushel to measure it with, and such bushel measure must be stamped by the inspector, after comparing it with the standard, before it can be legally used. All such various local measures must be ultimately referred to a legal standard unit. I may illustrate this by referring to the evidence appended to the Report of the Committee of 1862 on weights and measures (p. 27), which I have placed before the Commission. The bushel is a measure of capacity used for determining a given quantity of wheat. But the value of the wheat consists in the amount of farinaceous matter which it contains, and that is determined by its weight. It was shown to the Committee of 1862, that in 18 specified places in the kingdom, wheat was sold by the bushel containing different weights from 60 lbs. up to 168 lbs. But in all these cases the qantity of wheat sold, though nominally by the bushel, was never determined by the bushel measure, but by legal weights, multiples of the standard pound. An analogous case, showing such practice not to be illegal, was decided by the Court of Exchequer in 1854, re Jones v. Giles, where the point in dispute was the validity of a contract for the sale of iron by "long weight," or the customary weight in the iron districts of 120 lbs. to the cwt. instead of 112 lbs. The court held that, although there was great obscurity in the Acts upon the subject, such contracts were valid, not being in contravention of the weights and measures laws.

11,713. Taking the measures of differences in acreage which are calculated with different roods of different lengths, I have in my neighbourhood three several measurements by acres which affect land, coal, and minerals, and it requires some larger measure of information than is common to calculate the differences between those measures?—I wish very much to establish a broad distinction between weights and measures actually used, and the modes of computing by weights and measures, which are quite a different thing. With regard to the measurement of land and the different acres, the Scotch acre and others, the measurement must actually be made by the legal yard or foot. It is in the mode of computation by legal measures that the real difference of local and customary measures consists. The parties agree upon a different unit of measurement from the legal unit, though derived from it. Thus, with regard to the measurement of land, it was also shown to the Committee of 1862 that the unit of superficial measure of land, the acre, in six different parts of the kingdom, varied from 4840, the legal acre, up to 10,240 yards, which is known as the Cheshire acre; and so with roods. But the actual measurement of land, in order to compute the required number of acres or roods, must be made by the legal measure of the yard or foot, or the legal chain of 22 yards. No other means of measurement exists, whatever may be the locally or customarily computed acre or rood.

11,714. Taking into account the great influence of traditional custom as to the local weights and measures by which agricultural and mining transactions are carried on, and taking into account the degree of intelligence of the classes transacting business upon this basis, do you not conceive that it would be important in any Act of Parliament passed with the view to secure uniformity of weights and measures, that it should be required that every elementary school should be made the means of diffusing information upon the subject?—I think it most desirable that that should be done, because, at present, under the Weights and Measures Acts of this country, the only means of enforcing the provisions of those Acts has been by the action of the local inspectors. Those inspectors only act upon a certain portion of the population, those who buy and sell by open trade use of weights and measures, and there is no machinery for enforcing the Act and obtaining uniformity of weights and measures at present throughout the great mass of the community. It appears to me that the only way in which that can be done is by proper education upon the subject, and by bringing models of the weights and measures in use before the eyes of the people when they are young and when they are growing up. I may add that, with regard to carrying out an uniform system of weights and measures in this country, I deem it absolutely necessary that the views of the Standards Commission should be carried out, under which, whilst the general principles are to be laid down by law, the details should be in great measure left to the responsibility of the executive Government. That is done at present throughout the North German Empire, where they are not only substituting an uniform system of weights and measures, the metric system, in place of a great diversity of weights and measures throughout the different states, but they are also introducing a uniform method of dealing with those weights and measures. Their standards commission is appointed in Berlin, consisting of many eminent men of science and of technical and practical men who have followed the example set by France when the metric system was established there, and have drawn up a large number of regulations upon the subject, copies of which have been sent to me. I have translated the whole of them into English, with the view of their being studied in this country, and aiding the framing of regulations to be adopted here. A portion has already appeared appended to the fourth report of the Standards Commission, and the remainder will appear probably in my annual report for this year, which is now in progress. Amongst other things, they endeavour to meet the views of persons who have been accustomed to particular weights and measures in certain localities, and in their regulations they draw up rules for the construction and mode of verification of special measures and measuring instruments which are used in particular trades, for instance, in mines. They have their barrow measures, their cart measures, and their tub measures. They have gone very closely into the subject, so as to provide what the public require in such matters, and they have endeavoured to carry out a very efficient system in all its details

H. W. Chisholm, Esq.

7 June 1872.

by means of a code of regulations authorised by the general Act.

11,715. That is itself an illustration of the extreme difficulty of carrying immediately into execution any scientific measure for securing uniformity of standards?—Certainly it is, that is one example; and other examples are continually presented to my notice; but I am convinced that the whole matter is now ripe for decision in this country, where it is very much needed.

11,716. (*Chairman.*) Is there anything further upon the subject of gas measuring standards which you would wish to state to the Commission?—The gas measuring standards are really scientific instruments, and require, in their manipulation, careful attention to, and allowance for, the influence of temperature and atmospheric pressure. A great deal of attention has been given to them, and I think now that they are as perfect as we can expect them to be.

11,717. I think I understood you to say that in the country generally gas is not sold by those standards?—What I stated was that in the country the law relating to them is very imperfectly carried out. Under the Sale of Gas Act of 1859, no meter, unless duly stamped by an inspector as being in accordance with the standards, was to be fixed for use after 13th October 1861, or to be in any way used for measuring gas after 13th October 1870. At the present time, therefore, no meter is legal for measuring gas unless it is stamped as agreeing with the standards. But some amendments are required in the law both with regard to the construction of gas meters and the machinery for their proper verification and inspection. The Standards Commission have made a number of recommendations with regard to gas measures, as they have with regard to other weights and measures. The inspectors of gas meters who are appointed are a distinct class of persons from the inspectors of weights and measures, although they are in the same way subordinate to the different local authorities; but practically there is no supervision over them. Evidence was produced before the Commission to show that their duties were very imperfectly carried out, and that the verification of gas meters by them by means of copies of the standards was very imperfectly and improperly done. We have recommended that all their duties should be carried out under a code of regulations from the Standards Department, and that there should be also a supervision of their instruments, and of the mode in which they carry out their duties. We think that that is absolutely necessary before the system can be properly brought into working throughout the country.

11,718. A great number of gas companies are private undertakings, not under the authority of Acts of Parliament; does the Act apply solely to gas companies which are under Acts of Parliament?—I think that there is no supply of gas to any place in the kingdom where money is charged which is not under a special Act of Parliament, and the misfortune is that they have taken the opportunity of introducing clauses into those local Acts that completely nullify the provisions of the general Acts. I called the attention of the Standards Commission and the Board of Trade to the objectionable practice, which I think is a great public evil, of obtaining special local powers by private local Acts of Parliament, contrary to the general provisions of public Acts.

11,719. (*Dr. Sharpey.*) Surely there must be many gas companies in various parts of the kingdom that have not special Acts of Parliament for their constitution?—I am not aware that there is a single case. They usually have to come to Parliament for powers to purchase land, and for entering upon property in order to lay down their pipes.

11,720. (*Chairman.*) How do you obtain your thermometers, and what guarantee is there for their accuracy?—We get them from the best makers, and we have them verified as far as we can. We have had them verified both at Greenwich and at Kew, and we then compare them, the one with the other, so as to obtain a certain degree of accuracy. But at present it appears to me that we want a better guarantee for their accuracy. I know of no standard thermometer. The freezing point, or the temperature of melting ice, and that of boiling water, are really the two standards upon which they are based, and the intermediate parts are done by calibration. What we must depend upon in our standard operations is the rate of expansion of the mercury in a glass tube; and that is not satisfactory, because supposing it to be ascertained with perfect accuracy, it only tells you the rate of expansion of the mercury as indicating the temperature of that particular glass and mercury. What we want to apply it to is to our measures of length, and our gas standards, and we have between the two a layer of air. If we could obtain a better method of ascertaining the temperature of the air, we should get one step nearer. There are also metallic thermometers (what are known as Borda's thermometers), by the indication of the different rates of expansion of two metals, such as brass and of iron; and there is a beautiful scientific instrument that we propose to use at the International Metric Commission in Paris, which is a self-registering galvano-thermometer. The metric system of weights and measures has one great advantage over the imperial system with regard to the determination of the accuracy of the standard temperature, although there are many other disadvantages attending it. The standard temperature of the metric system is the temperature of melting ice, the zero of the centigrade thermometer, and that is much easier to ascertain than any intermediate distance. Our standard temperature is 62 degrees, Fahrenheit, or $16\frac{2}{3}$ of the centigrade. There is an important practical advantage in this standard temperature, because it is much nearer the average temperature at which all weights and measures are used; but it is not nearly so easy to determine. and practically, I suppose, we cannot depend upon any of our thermometers to the tenth part of a centigrade degree, as indicating the temperature of our standards.

11,721. (*Professor Smith.*) You find that the mercury in two thermometers will not agree nearer than that?—We cannot depend upon them, but we endeavour to reconcile any uncertainties of that kind by always using two or three thermometers, and taking the mean temperature indicated.

11,722. Did you have the same thermometer verified both at Greenwich and at Kew?—Yes, the same instrument at both places.

11,723. (*Chairman.*) Has there been a question of providing an air thermometer for the Standards Department?—It was thought very desirable that there should be an air thermometer, and I was requested by the Standards Commission to place myself in communication with Dr. Balfour Stewart upon the subject. The matter is referred to in the proceedings of the Commission at the meeting of the 21st of July 1869. It was left to me to make the necessary arrangements with the President of the Royal Society, who was requested to superintend the construction of an air thermometer at the Kew Observatory. I had a communication afterwards from Dr. Balfour Stewart, which is thus referred to at the meeting of the Commission on the 3rd December 1869. "The chairman read a letter from Mr. Balfour Stewart stating that the Kew Committee had resolved that the construction of a standard air thermometer necessarily involved a number of preliminary experiments, the extent of which it was impossible to foresee. The cost would probably not exceed 250*l.* The committee were prevented by pressure of other business from undertaking these experiments till after a period of six months." They thought that we ought to have a credit of 200*l.* to begin with. Our Commission considered that objections would be raised at the Treasury against starting with an expenditure of 200*l.*, and that we had better proceed no further with the matter.

11,724. Has nothing been done subsequently?—

H. W. Chisholm, Esq.

7 June 1872.

Nothing further has been done at all with regard to the construction of an air thermometer.

11,725. (*Professor Smith.*) Was your object in obtaining the air thermometer to verify your own mercurial thermometer by means of it?—Partly to verify them, but chiefly to use the air thermometer for determining the temperature of the air. For instance, in our standards of volume we have to compute the exact temperature of the air in passing from one gas-measuring standard to another, and to make allowances for the actual temperature in order to reduce it to the standard temperature. It is very material in measuring large quantities of air that we should be able to ascertain its exact temperature, and that could certainly be done with much greater precision by means of an air thermometer than by the use of the mercury thermometer.

11,726. (*Chairman.*) How do you supply yourselves with barometers?—It is very necessary to have very accurate barometers for all our observations of weighing when we have to determine the weight of air displaced by the standards. We obtain our barometers from Negretti and Zambra, and we also get them verified at Greenwich, where they have, I believe, a standard barometer, but we have now adopted a further method of checking the accuracy of our ordinary barometers. We have got a syphon barometer and cathetometer, which we propose to make a standard measure, by means of which we can measure most accurately the height of the mercury in the two columns, and thus check our ordinary barometers when we want great precision; but it is only in the verification of primary standard weights that we have to be so very particular in determining the actual weight of the air displaced.

11,727. (*Professor Stokes.*) Do you make any use of the siphon barometer as a standard by which to check your own barometer?—Yes.

11,728. Are you satisfied about the construction of that barometer?—It is extremely simple. But we never depend upon one barometer. We have two, and we very soon find out if one barometer gets out of order because of the discordance between it and the other. We have the actual errors of each barometer certified to us, and in comparing the two if there is any discordance beyond those errors we should at once say that one barometer is getting out of order. We found that to be the case some time ago, and on sending to Negretti and Zambra to examine it, it was ascertained that there was a little oxidation, and that the barometer wanted repairing.

11,729. Has each of the barometers been verified at Kew?—At Greenwich, not at Kew.

11,730. Is each compared with the Greenwich barometer taken as the standard, and then great care used in the transport so as not to introduce the air?—Yes; Negretti and Zambra undertake that, and to deliver it to our office in a perfect state for use after it has been verified.

11,731. (*Chairman.*) How far can you depend upon your balances?—Our balances are of the very finest construction that they can be made, and every care is taken of them; but such balances are extremely sensitive instruments. They are so susceptible that their action is deranged by many small accidental circumstances. It will be deranged by the currents of air in a room of variable temperature, and by any slight vibration of the air. We find that a heavy waggon passing near the office immediately shows its effect on our fine balances; and the very action of the balance discomposes it to a certain extent. We are obliged to observe whether the action is gentle or more violent, because unless we make allowances for that, we have certain discordances in the results. The action of light even tells upon the balance. We always make a certain number of comparisons, and take the mean, at the same time observing what discordances there are in the several comparisons; and if the discordance is considerable, we know that there is something wrong that requires remedying. There are sometimes considerable discordances in the results of our weighings, and it is only by the very greatest care, and by long experience, and by taking the means of observations, that we can depend upon results. But we can depend upon results by taking a certain number of observations; and that has been proved by the observations and operations in the reverification of our standard weights. In 1867, we compared a platinum troy pound weight which we have with the platinum troy weight of the Royal Society. Those two weights had been compared together in 1844 by Professor Miller, and he had taken four series of observations, each series consisting of about 20 comparisons, so that there were about 80 comparisons made under different circumstances, and he had arrived at a mean result of the difference of the weight of those two platinum pounds in a vacuum. It was very important to prove whether there had been any relative alteration in those platinum weights in the course of 24 years,during which period they had been kept at different places; and we, therefore, made a similar series of observations to those of Professor Miller in 1844. The result was that our mean agreed with Professor Miller's mean to the $\frac{1}{1000000}$th part of a grain, proving that no alteration had taken place in those two weights; and that result was accepted by the Commission. When I say that we agreed to the $\frac{1}{1000000}$th of a grain, that was a happy accident, because the probable error of the result was greater than that, being $\frac{5}{1000000}$ths of a grain, but you will see that it was considerably within the probable error.

11,732. What means have you of ascertaining the rate of 'expansion by heat of your standards and other materials used in comparisons of standards?—That is an important part of our duties. At present we have several copies of the imperial standard yard that were constructed under the Commission of 1854, and the rate of expansion of the bars then used was determined by Mr. Sheepshanks, and each bar bears the temperature at which it agrees with the standard. The Imperial Standard is of the true length of a yard at the temperature of 62 degrees of Fahrenheit. One other bar was made, which was of exactly the same length, that is to say, it agreed within the $\frac{1}{100}$th part of a degree of Fahrenheit. Other bronze copies varied more or less, but none to the extent of half of a degree of Fahrenheit from the true temperature. That maximum deviation is equal to 0·00017 inch, at the accepted rate of expansion of these bronze bars, viz., 0·000341 inch for 1° Fahrenheit at ordinary temperatures. In all our observations when we are comparing standards of two different metals, for instance a platinum and a brass bar, or a brass and an iron bar, if we have with our imperial measure to refer to a temperature of 62 degrees, and find the bars, for instance, at the temperature of 59 degrees, we must make a computation for 3 degrees of the different rates of expansion of the bars. We have at present no other means of determining the rate of expansion than by comparing them at different temperatures, and computing the rate from the differences of length. I am now having an apparatus constructed by which we can ascertain, in a different way, the rates of expansion, by having a standard at a definite temperature, that is to say, a steel bar with two points at a yard's distance from each other, to be kept constantly, when required for use, at the temperature of melting ice, or the zero of the centigrade scale. By a contrivance we place the bar to be compared underneath the standard, first at the same temperature, that is to say, as the temperature of melting ice, and bring it up and mark the length of a yard at zero on the bar at zero. We next raise the temperature of the bar under comparison to boiling point, and, in the same way, when it is at the temperature of 100 degrees of the centigrade scale, we mark the two points of a yard at zero, and can do the same at intermediate temperatures of the bar; and then, by measuring the distances between those points on the bar, we determine the rate of expansion. In the International Metric Commission at Paris much con-

H. W. Chisholm, Esq.

7 June 1872.

sideration has been given to the question of expansion of measuring bars by heat, and we hope, at our next meeting, to have an actual standard of dilatation, that is to say, a bar of beryl with the measure of not less than two decimetres marked upon it, or about 8 inches. Beryl, as the Commissioners are probably aware, is very little affected in its dimensions by heat. There is hardly any substance that dilates less than beryl, but it has this peculiarity that it expands by heat in the direction of its axis of crystallization, and it contracts by heat in the direction perpendicular to the axis of crystallization, and between the two it is perfectly possible to draw a straight line, or mark two points, in the direction where there would be no change whatever in the length by heat. If we once get such a standard of dilatation, and mark, as we propose, a distance of two decimetres upon every measuring bar to be constructed, we shall at once, by a very certain method, be able to ascertain the exact rate of expansion by heat of every standard measure that we have to deal with.

11,733. Have any steps been recently taken for redetermining the weight of a cubic inch of water? —That is a point which has been brought prominently before the Commission in Paris, and the several members have been requested to make as many observations as they can for the benefit of the Commission. It is proposed that a number of experiments shall be carried out for this object at St. Petersburgh, by Dr. Wild; at Berlin, by Dr. Förster; at Berne, by Dr. Hirsch. I propose also to make similar experiments here, so that we shall, I hope, be able to obtain a more authoritative and exact determination of the weight of a cubic inch of water than has hitherto been done. That is very important as regards the metric system, more so than as regards our own imperial system, although the value of all our gas-measuring standards is dependent upon it; but in the metric system the relations between the weights and measures of capacity are dependent entirely upon the ratio of the weight of water to its bulk, and it is very important for the metric system that that should be very accurately ascertained. It is very fortunate that of the five authoritative determinations of the weight of a cubic inch of water which have been as yet made, that of Kuppfer, which is the most elaborate and the most recent, agrees very nearly indeed with the original determination by the French Commission of weights and measures, who founded the metric system. It is probable that the original determination by the French Commission is very nearly the truth, and much more near the truth than Sir George Shuckburgh's determination, which was adopted in this country, and by the legislature.

11,734. What means do you adopt for guarding against atmospheric and other influences on standards? —Such influences affect more particularly our standard weights, and we have great difficulty in that respect. For instance, in the new standards which have been recently made of brass or bronze, we find that there is a considerable increase at first from oxidation. We have endeavoured to guard against any consequent injurious results of alterations in their weight, by comparing them from time to time with our old brass standards which have become saturated with oxygen upon their surface; and we can thus ascertain if any and what alterations occur in our working standards. Those alterations are not large enough to affect in any way the commercial weights that are used, but still it is important that our standards should be as accurate as possible. I hope, by a method lately discovered of coating brass or gun metal weights with pure nickel upon which the atmosphere has no effect whatever, we shall be, to a certain extent, much more independent of atmospheric causes than we have hitherto been. We take every precaution we can to preserve our standard weights from being affected by such influences, by keeping them covered up, and thus protecting them from air and moisture.

11,735. Is the building, in all respects, in which the business of your department is carried on, suitable for the purpose?—It is upon the whole very suitable. The strong room where we keep the standards is as secure from its position as it can be, and it is pretty nearly fire-proof for it is in the basement and arched over. It was examined very carefully by the Standards Commission, and they entirely approved of it. The rest of our rooms we have added by degrees, and particularly those rooms in the old tower, which are remarkably stable and of equable temperature. We had the ground underneath the basement excavated and laid down with 14 inches of cement so as to have a perfectly solid foundation. The walls are about five feet thick, and we have had double windows put up, and the building is upon the whole very satisfactory for the purposes required.

11,736. Will you be so good as to state the precise object of the International Metric Commission at Paris? —The primary object of the commission is to construct and verify a considerable number of metric standards of the metre and the kilogramme, so that all nations who at present use the metric system or contemplate its use shall have accurate and uniform standards. The existing primary metric standards are very well as a point of departure, but they are not such good standards as may be made now, either as regards the material of which they are constructed or their mode of construction and verification, and they may be very much improved upon by the appliances of modern science. We hope that that will be done, and that by each country being furnished with uniform standards a great step will be gained towards the uniformity of weights and measures throughout the civilized world. At the same time there are a great many scientific questions relating to the construction and use of standards that come before the commission, and as the commission is composed of scientific men from all parts of the world, all those questions are receiving great consideration and I hope eventually elucidation.

11,737. Are you a member of the commission?—I am.

11,738. Are there any other English members?—Yes, the Astronomer Royal and Professor Miller.

11,739. How long has it been sitting?—The commission met for the first time in August 1870, just after the commencement of the war between France and Germany, according to arrangements made some time before the war broke out. It was agreed at once, and we passed resolutions to that effect, that nothing definitive should be done until after the close of the war, when we could have the benefit of the presence of the German members. We continued, however, to sit for a week discussing the several points of our duties, and there was also appointed a committee of preparatory researches. After the close of the war, and when tranquillity was restored at Paris, the French section of the committee met from time to time; and last March there was a meeting of the preparatory committee, at which Professor Miller and I attended. We sat for about a fortnight, having before us the results of a great many experiments that have been made with regard to metals, comparing instruments and the best method of using them. We agreed upon a great many points, so far as reporting our views upon the subject to the next meeting of the commission, which is fixed to take place on the 24th of September, and we hope then to have a very full meeting, and at once to commence the operations of constructing the standards.

11,740. Are you members of the commission in virtue of any Government authority? —The commission was originally appointed by the Emperor of the French, in consequence of some resolutions of the Geodesical Congress at Berlin, and afterwards of the National Academy of Science at St. Petersburg, upon the subject of New Metric Standards; and in consequence also of the recommendation of our Standards Commission for introducing the metric system into this country. The matter was taken up by the National Academy of Sciences in France, and they recommended to the French Government that an Inter-

H. W. Chisholm, Esq.

7 June 1872.

national Metric Commission should be appointed to have all those subjects referred to them. The result of these preliminary steps was that a report was made by the French Government to the Emperor, and sanctioned by him, by which the French section of the commission was appointed, consisting of eight eminent men of science in France; and at the same time the French Government were directed to communicate with all foreign Governments, to ask them to appoint delegates from each country to take part in the commission. Delegates have accordingly been appointed from most of the civilized countries; and I think at the present time that there are 45 members of the commission, representing 22 of the principal countries in the civilized world.

11,741. (*Dr. Sharpey.*) Who appointed the representatives for England on that commission?—A communication was made from the French Government to their Ambassador in London and by him to the Foreign Secretary of State here.

11,742. Was it through the Foreign Office that the appointment was made?—No; the communication was made to the Foreign Office, the Foreign Office referred it to the Treasury, the Treasury referred it to the Board of Trade, and the Board of Trade referred it to me, and I brought the matter before the Standards Commission then sitting. I stated to them that it appeared to me the subject was rather of a scientific than of a diplomatic or a political nature, and that as the object of the commission was analogous to the object of the Standards Commission here, I thought that I should best discharge my duty to the Board of Trade by bringing the subject before them, and having the benefit of their advice and assistance. The matter was consequently taken into consideration. It is referred to at length in the minutes of proceedings, and it was thought by the Commission that it would be of great importance to this country that we should take part in the commission, and that it would be most advisable that three members should be appointed, the Astronomer Royal, Professor Miller, and myself. I communicated a resolution to that effect to the Board of Trade, and they quite concurred in it, and it was referred to the Treasury. The next thing we heard of the matter, to our great astonishment, was through a letter I received from one of the members of the French section of the commission, with whom I had previously been in communication upon the subject, to say they had just been informed by the French Government that in answer to their invitation the British Government had declined having anything to do with the commission, on the ground that the metric system was not yet legalised in this country. General Morin said that he was quite at a loss to understand the decision of our Government, and that it would tend to injure the interests of science and their advancement in the two countries; and he asked me if I could not take some steps to have the decision of the Government reconsidered. After bringing the matter before the Board of Trade and before the Standards Commission, the result was, that I was requested to draw up a paper upon the subject, stating reasons why the Government should reconsider their decision. This paper was forwarded to the Treasury by the Board of Trade, and eventually the Treasury said that as it seemed to be considered by the Board of Trade and the Standards Commission to be of National importance, they would agree to the appointment of the members of the Commission.

11,743. Was it the Treasury that finally nominated the commission?—No; it was the Government who confirmed the recommendation of the Standards Commission.

11,744. Which department of the Government; was it the Treasury or the Board of Trade?—The appointment was communicated to the French Government through the Foreign Office, but it was really the Treasury that decided the appointment, because it involved a question of expenditure of public money.

11,745. (*Chairman.*) If the Standards Commission had not happened to have been in existence at the time, probably this country would have taken no part in this International Commission?—The probability would have been that this country would have taken no part whatever in the commission, and would have been entirely excluded from it. It required a considerable amount of pressure upon the Treasury authorities to get them to consent to it.

11,746. You think that the appointment of a permanent scientific commission or council would increase the efficiency of the Standards Department in carrying out its scientific duties?—I consider it to be almost indispensable for the proper conduct of the scientific duties of the department, which arise at certain times, that there should be some scientific authority, such as a permanent scientific commission or council, to appeal to for aid and support.

11,747. Do you contemplate in this question a commission solely with reference to the efficiency of the Standards Department, or a scientific commission for the general purposes of science?—Certainly a permanent scientific council or commission for the general purposes of science. It would never be worth while, merely for the few occasions upon which their aid may be required in the Standards Department, to have a permanent commission. It appears to me that my department is only one of several Government departments that will most likely come under the notice of the Commission, who must be better judges of this question than I can pretend to be. You have, as it were, to construct the edifice, and I can only contribute a brick or two towards it. Certainly I feel the want of such a commission very much with regard to my own department; but there must be also several other departments of the Government with respect to which it would be very advisable that there should be such a council.

11,748. Have you any recommendations to offer as to the constitution of such a commission?—I can hardly venture to give any suggestions of that kind. As far as my own department is concerned such a council or commission would be available only as a consultative body, and for counsel and support. I am not at all aware what administrative duties would properly belong to such a commission, and, therefore, I can hardly venture to give any suggestions on that point. I see the general want of it very strongly; but I do not quite see my way as to how the want is to be met.

11,749. (*Dr. Sharpey.*) Do you consider that the establishment of national laboratories for conducting physical and chemical experiments would be in any way serviceable to the Standards Department?—I have no doubt that they would be very serviceable. I may bring before the Commission an analogous case in France. There they have the National Academy of Sciences to whom these kind of questions are referred by the Government, and they have the different sections of the Academy. There are six members assigned to each section, and whenever a question is referred to the Academy by the Government, it is referred to that particular section which it more immediately concerns. Amongst these is the chemical section, a prominent member of which is M. Henri Saint Claire Deville, who is the head of the École Normale, and is also a member of the International Metric Commission. His services have been most useful to the Commission, and he has been making a number of observations and experiments in his laboratory upon different metals and their alloys, as well as their manipulation.

11,750. So that he uses the laboratory at the École Normale for making those investigations?—Yes. On one occasion, during the meetings of the committee, we met at the laboratory, and he went through a number of experiments to show us exactly how the working of certain metals was effected, and how they were fused together. Those were alloys of platinum.

11,751. Is there any place in London or in England where such experiments could be carried on, supposing you desired them?—I do not know that there is, except, perhaps, at the School of Mines; it may be

H. W. Chisholm, Esq.

7 June 1872.

done there. When I was called upon to prepare the new standard trial plates, one of the first persons I applied to was Dr. Percy, at the School of Mines, professor of metallurgy, and it also occurred to me that I might have the assistance of the Royal Society working through the School of Mines, where they have a laboratory; but the Astronomer Royal, the President of the Royal Society, declined to interfere in the matter, so that it fell to the ground. There are many occasions on which such a laboratory would be very serviceable to my operations. Perhaps I may refer here to a question of some importance, which was raised in the United States of America. Dissatisfaction had been expressed at the mode of proving and gauging alcoholic liquors there. It was placed under the Standards Department, which is the Coast Survey Department, and I have here the report at considerable length of the National Academy of Sciences upon the whole subject of proving and gauging distilled spirits in the United States of America. The matter was referred to them by the Government, in the following letter of the Treasury Department, dated February the 15th, 1866, addressed to Professor Joseph Henry, Vice-President of the National Academy of Sciences, who is also a member of our International Commission at Paris:—" Sir, I have the honour to request that a " Committee of the National Academy of Sciences " be appointed to report to this department on the " best method of proving and gauging alcoholic " liquors with a view to the establishment of such " rules and regulations as may be necessary to insure " an uniform system of inspection of spirits subject to " duties. Yours very respectfully, H. McCulloch, " Secretary of the Treasury." They took a great deal of pains, as you will see by this book, to bring out a proper system, and the result has been that the Standards Department of the United States have, under their directions, constructed and verified a complete series of alcoholmeters for the whole of the Customs and Excise officers throughout the United States.

11,752. Are you aware that a good many years ago the Royal Society were consulted with regard to the construction of hydrometers for the Excise in this country, and that there was a great deal of work gone through by a committee of the Royal Society in compliance with a request of the Government?—I was not aware of that. I brought the question before our Standards Commission as to the expediency of having a standard hydrometer and saccharometer, and of having all those instruments verified; but the Standards Commission thought that it was a matter which did not come within their range, and they declined to have anything to do with it. At present there is no systematic official verification of those hydrometers and saccharometers. I have no reason, however, to believe that they are not sufficiently accurate. They are made by Oertling, and last week I was at his shop, and I saw a great number sent in for adjustment and repair.

11,753. (*Chairman.*) With regard to the preparation of the new standard trial plates, of which you have already spoken, I believe now you are endeavouring to proceed as well as you can with the assistance of the officers of the Mint and of the Goldsmiths' Company. Do you expect that the result will be satisfactory?—I hope that it will. The only alteration that we could possibly make was in trusting the preparation of the plates to the Mint instead of to the Goldsmiths' Company, and entrusting the subsequent verification to a sworn jury of the Goldsmiths' Company, as has been done before. It appeared to me that the officers of the Mint are continually employed in mixing metals, which is their daily work, and they have very large experience in that way. There are two scientific men there, Mr. Roberts, the resident assayer, and the assistant assayer. The Deputy Master of the Mint represented to me that he had very great confidence in their scientific knowledge, and his opinion was that the work would be better done at the Mint than by the Goldsmiths' Company. The Astronomer Royal concurred with me in that opinion, and upon it I have acted, and the preparation of the plates is now being proceeded with at the Mint. It will take a considerable time, probably many months, and there will be a great number of experiments, but I hope that the result will be much more satisfactory. The Commission, perhaps, is aware that these trial plates are used for the determination of the due fineness of gold and silver coins. The fineness is fixed by law. The gold coin contains eleven parts of pure gold and one part of alloy. There is rather a different standard of silver, which is 37 fortieths fine, or expressed millesimally 925·. The problem to be solved is to prove that those due proportions have been observed in the gold and silver coins made at the Mint; and that is done by referring, not to the theoretical composition of gold coins, for instance, being $\frac{11}{12}$ths fine, but to the actual comparison with the standard, which has been proved to be $\frac{11}{12}$ths fine. So that it becomes of considerable importance to have that standard as accurate as possible. As a further security, and as, perhaps, being a still better practical standard, although the legal standard is a standard trial plate of $\frac{11}{12}$ths fine, it appears that for the process of assaying it is also most desirable to have a standard plate of pure gold and one of pure silver, and such plates are now to be constructed accordingly. So that, in future, we shall have additional standard plates of pure gold and of pure silver to be used at the trial of the pyx, when the actual testing takes place by the sworn jury of the Goldsmiths' Company.

11,754. (*Chairman.*) Are there any other points upon which you would like to make additions to your evidence?—I do not think that there is anything more that I wish to say.

The witness withdrew.

Adjourned till Wednesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 12th June 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
BERNHARD SAMUELSON, ESQ., M.P.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

C. W. Siemens, Esq., D.C.L., F.R.S.

12 June 1872.

C. WILLIAM SIEMENS, ESQ., D.C.L., F.R.S., examined.

11,755. (*Chairman.*) The Commission would be glad to hear your opinion as to whether you consider it to be the duty of the Government to promote the advancement of science?—I think the Government should promote science.

11,756. Have you any recommendations to offer as

C. W. Siemens, Esq., D.C.L., F.R.S.

12 June 1872.

to the best mode in which Government encouragement could be afforded?—I think that one of the best modes in which Government could promote scientific education would be by endowing academical chairs liberally. By doing so they would get professors of high ability who would not be oppressed either by the excess of duties in the college or university, or by professional duties, but could devote a great deal of leisure time to research. Having regard to the interest of the taught, they would be able to bring more personal influence to bear upon the student: on that account I think it is desirable that men eminent for their power of research should in some way remain connected with establishments of tuition of the higher branches of physical science.

11,757. Would you confine the endowment of academical chairs to existing institutions, or do you wish to see additional institutions established in the country?—The existing institutions require, I believe, considerable aid, and I would begin with a liberal endowment of chairs in those institutions.

11,758. Do you refer simply to the Universities, or to such colleges as University College and King's College, in London, and Owens College, in Manchester?—Yes, I would include those.

11,759. You do not especially refer to the establishment of any similar institutions in other parts of the country?—The existing institutions, especially those which have been based upon the free action of individual interest in science, require Government aid in order to put them in a position of having professors of the first rank, men who are not to be dependent for their means of support upon other sources.

11,760. What is your view as to competitive examinations?—I think they have the effect, if carried to extremes, of lowering the mental capacity of the students, and to disgust them rather with learning than otherwise. It is not always the man who comes out best in an examination who has the greatest love for science, or who is able to produce original work. It would be better, I believe, to have frequent repetitions in teaching in order that the student should always be kept up to the work. That is a system which I know has been introduced into some German colleges with great effect; that is to say, weekly repetitions and final examinations only up to a minimum standard.

11,761. (*Professor Smith.*) What do you mean precisely by repetitions?—At the end of every week the subject-matter taught during the week in each class is repeated; questions are asked and the student is thus obliged to keep up with the professor, step by step.

11,762. Is it an oral examination in the subjects which have been taught during the week?—Yes. But on the other hand, the doctor examinations in Germany at the universities are generally based now upon the production of original work, an essay on new subject matter or a paper on any special question in science.

11,763. (*Chairman.*) In these observations, do you refer principally to the most advanced students, or would you like to see competitive examinations done away with in all cases?—Competitive examinations in the sense of ranking men entirely by the result of the answers they give, or selecting them to offices entirely by the result of those answers. For instance, in selecting people for a Government department, it is by no means certain that the five persons, I will say, who have passed at the highest numbers would be the most suitable persons for the duties they would have to perform, but, at the same time, an examination would be necessary, in order to show generally that they have acquired knowledge; but the selection should be not absolutely dependent upon the maximum result of examination.

11,764. (*Dr. Sharpey.*) What would you recommend that the selection should depend upon?—After a certain number of candidates had been selected as being all sufficiently informed for the appointment, the appointment should be left with the department to make according to the other qualifications which they might discover by trial or recommendation, in appointing simply those who appeared to be best suited for the work.

11,765. Would not those to whom the selection was entrusted go back into the history of the candidate, as to his educational worth, or how would they determine finally to select one rather than another; I mean apart from the examination?—All those who had passed the examination would be eligible for the appointment.

11,766. And then what would you make the further selection depend upon; what sort of test of fitness should be resorted to in making the selection?—Of course it is a difficult matter to select always the right person, but I would give the head of the department a great discretion in the matter.

11,767. The point which I think you wish to establish is, that it should not depend upon mere competition?—Not on mere competition.

11,768. (*Chairman.*) Did I rightly understand you to say that, from your observation, you consider that the system of competitive examination has not led to very satisfactory results?—I think that better results would be obtained by another system, such as I have endeavoured to point out.

11,769. What is your opinion as to the system on which fellowships should be obtained?—I think that fellowships should chiefly be granted to those who have shown capacity for original research, because in their hands the grants will be more productive than in the hands of those who have merely had the memory and other qualities that brought out the best results in examination.

11,770. Then you would think it desirable that, in all cases, those who obtained fellowships should have shown a capacity for original research?—Yes; in addition to the necessary positive knowledge determined by a minimum examination.

11,771. Will you give us your opinion as to the mode in which the Government might encourage scientific research?—The Government might promote original research by liberal grants to the learned societies; that is done now to some extent, but I think it might be done with advantage to a greater extent; also by granting, through societies, rewards for successful results obtained by independent research. In many instances the Patent Law provides for the reward, but in other cases of pure science the Patent Law does not apply, and the results of original research are left unrewarded.

11,772. Would you recommend that definite sums should be offered by the Government to the learned societies to enable them to make such use of them as they think fit?—Certain limits might be imposed up to which the learned societies might be empowered to grant aid in the prosecution of scientific objects.

11,773. You have stated that the Government already does something in this direction; in what way does the Government make grants to the learned societies, except through the 1,000*l.* grant placed annually at the disposal of the Royal Society?—The British Association, I believe, receive certain aids. They used to get the grant of the Kew Observatory. I am not aware whether other societies get any positive grants, but they get facilities such as the grant of a locality for their meetings. But I think the system of grants might be with advantage extended to other societies, such as the Chemical Society, the Astronomical Society, the British Association, and so on. The British Association especially produce very considerable beneficial results through their grants.

11,774. (*Professor Stokes.*) You mean through the grants that they make out of their own funds?—Yes, out of their own funds; and if those means were increased by the Government, greater benefit might be obtained.

11,775. (*Chairman.*) Would you also recommend that the Government should assist the societies in publishing their proceedings?—In some cases the proceedings are very costly. I believe the Zoological

C. W. Siemens, Esq., D.C.L., F.R.S.

12 June 1872.

Society publish their proceedings, which are very costly, and there the funds of the Government might probably also be usefully employed. I mean in all cases where many illustrations are required.

11,776. The Zoological Society happens to be a society that is financially very prosperous, is it not?—I suppose they are.

11,777. (*Dr. Sharpey.*) Are the Linnean Society very much in the position that you refer to; do they require aid?—Yes, in all cases where expensive illustrations are required.

11,778. Have you ever compared the extent and quality of the illustrations published by our societies with those on the continent; for example, the Academy of Sciences of Vienna, and some other foreign societies?—I have made no comparison of that description.

11,779. (*Chairman.*) Will you proceed to your next recommendation?—The Government might aid scientific investigation by nominating special commissions or by enabling learned societies to undertake special scientific inquiries such as involve a large expenditure of the means and the time of the investigator, or those where information must be obtained through evidence. A Government commission has it in its power to collect information where private individuals would not, by calling before them persons to give evidence. But I would confine such inquiries to special objects of national importance. I would not extend such inquiries to matters of ordinary scientific research.

11,780. You mean that in certain cases the councils of the societies might, so to speak, be converted into special commissions for special objects?—Yes, that is to say, committees nominated by learned societies or committees named, as is now the case, by the Government directly, with the aid of the learned societies.

11,781. Do you think it desirable that our Government should co-operate with foreign governments in the collection of scientific information?—I think a great deal might be done in that way if the Government were to call upon foreign governments to supply statistical information; for instance, on subjects connected with meteorological observations and magnetic observations. All such information would be extremely useful, and the Government alone could efficiently obtain it from other governments, or from foreign societies through those governments. Another desirable object, I think, would be to establish an International Patent Law. At present patents for inventions are granted in this country irrespective of what is done in other countries. Certain countries have very good patent laws, and others have hardly any at all. Germany has hardly any patent law, and the result is, that inventions are either carried over from this country to Germany without rewarding the inventor here, or if they are of German origin and the inventor has not brought his invention to this country, he works it in Germany as a secret. In both cases the British public suffer, and the invention becomes in the one case not remunerative to the British inventor, and in the other case it remains unknown in this country; therefore, I believe it would be desirable that an international arrangement should be arrived at (and I believe that there would be no very great difficulty in doing so), to make patents granted in one country be extended also to other countries.

11,782. (*Sir J. P. Kay-Shuttleworth.*) You would have a common law of patents?—A similar law in all civilised countries.

11,783. Are you aware whether the secret of any invention of great importance has been long maintained in Germany?—Being secrets, it is difficult to get at the facts, but probably great inventions would not long remain secret, because the owner of the secret would bring it to England and patent it, but minor discoveries or inventions have remained secret; for instance, in Mr. Krupp's steel works certain processes are not shown at all, and the results there obtained clearly indicate certain improved processes which are unknown to others.

11,784. But as respects great inventions, the secret, you think, would not be maintained?—It would be the interest of the inventor to bring it at once to the great market.

11,785. (*Mr. Samuelson.*) The German Governments of course have considered their policy in restricting the granting of patents. Do you think it is probable that they would be willing to modify that policy at the instigation of another country?—I believe so. There is an inquiry now going on, and I imagine that the commission appointed in Germany will be very much influenced by the report of our committee in the House of Commons.

11,786. Then, in point of fact, we may take it that the question of policy is entirely an open question at this moment in Germany?—The freetraders are for abolishing the patent laws, because they say they are monopolies, and we are against all monopolies. But I think that such arguments as were used before your committee must convince them that patents are not necessarily monopolies, but that they are simple payments in return for benefits received, or necessary reservations of right, for the benefit of the public.

11,787. (*Chairman.*) Have you any reason to think that proposals from this Government for co-operation with foreign governments in the various ways which you have indicated would probably be favourably entertained?—I think that foreign governments would be very well disposed to co-operate with the English Government in any object for the promotion of science.

11,788. Has anything of the kind been adopted amongst other foreign states in which England has not yet taken a part?—I am not aware of any agreement between foreign states in which England is not a party, but there have been telegraph conventions held which England has joined lately, where matters relating to telegraphy are arranged for all nations, and on the same basis other questions of common interest could be dealt with, and would be freely entertained, I believe.

11,789. Are you of opinion that any of the public departments could be utilised to a greater degree than they are at present for collecting scientific information?—I think they could, by a system of bringing that information into one focus, and by directing the departments especially towards objects of inquiry, which it would be desirable for them to undertake. I have prepared a list of the different departments which would be suitable, in my opinion, for collecting scientific information. The royal observatories, of course, would continue their present activity in that direction, but with the understanding that their researches would be brought more into juxtaposition with the researches of other departments for publication. An observatory or several observatories should be established for carrying on physical research, research to obtain information on general subjects, such as solar observations, magnetic observations, and other subjects that might be thought desirable to obtain continually information upon. Then the Meteorological Department might be with advantage extended, I think, although I am not sufficiently conversant with the details of the working of the present Meteorological Board to say what those improvements should be, but a thorough and continued investigation of atmospheric phenomena would be of the highest importance and may lead ultimately up to the prediction of atmospheric changes with great certainty. Then another department, which exists already, but which might, perhaps, be made more generally useful, is the Hydrographer's Department; another, the Trigonometrical Survey Department; the Geological Department and the Zoological Department in connexion with the British Museum.

11,790. In the Geological Department? Do you refer to the School of Mines?—The School of Mines and the Geological Survey. The Sanitary Department is one of great importance, and involves a great many scientific inquiries, which should be made and published. Another department might be devoted to

C. W. Siemens, Esq., D.C.L., F.R.S.

12 June 1872.

naval construction, which is at present not considered in the light of a scientific department, but which might, I think, with advantage, be made into such a department, because there are a great many questions of scientific import involved, which could be more fully solved by long-continued experimental researches and the publication of results. Another one is the Department of Fortification. Perhaps that might not be altogether considered in the same light as some of the others, but still there is a distinct science, and the results of experiments made by that department are actually published, and may, therefore, without impropriety, be treated in the same way as those produced by the other scientific departments. Another Government scientific department should be established in connexion with telegraphy. The telegraphs have now passed into the hands of the Government, and the information which can be collected through that department is not now made sufficiently available for further research. There are two branches, the civil and military telegraphs, both in the hands of the Government, and both should, I think, be joined under one scientific department. Another department which might be extended with advantage is that of the standard weights and measures, to which might be added thermometers, barometers, rain gauges, tide gauges, and electrical units. A department with all those elementary instruments under their care would, I think, be of great advantage. Joined with those would be the department for general education. Then, perhaps, another department might be added, that of publication, setting apart an office altogether for editing and publishing the information that might be collected through those different departments. Each department should, of course, be placed under responsible heads, and I would put very considerable personal responsibility upon the head of each department.

11,791. Some of those departments at present publish annual reports, do they not?—I am aware that they do.

11,792. Do you think that such reports should be fuller than they are at present?—They should be fuller and collected, I think.

11,793. From all departments you would have the results collected together?—Yes.

11,794. And those that do not now present any reports, you think, should in future present reports?—Yes, they should in future present reports.

11,795. You would place each department under a responsible head. Would you place all the departments together under any special minister?—I think that there should be a superior head with the title perhaps of minister for science and education, in order to guide the whole, and to make the information obtained by each department flow back to the other departments and to the public generally for information.

11,796. You would remove, for instance, the Royal Observatory at Greenwich from the Admiralty, and place it under the Science Department?—Yes, but some of them, for instance, fortification, would have to remain to a certain extent under the Minister of War, but still in all matters relating to scientific inquiry it might be brought under the Department of Science. Then, I think, that it might be advantageous to assemble the heads of those departments, at frequent intervals, for the discussion of general questions, and I would propose to add to their number such men as the President of the Royal Society, the President of the Institution of Civil Engineers, and at least one representative of the two great Universities. This board would decide general questions appertaining to the advancement of science.

11,797. Have you considered how far Scotland and Ireland would be satisfied with a Council so constituted as you recommend? You propose the President of the Royal Society, the President of the Institution of Civil Engineers, and at least one representative of the two great Universities. Do you think that Scotland and Ireland would be satisfied with a Council so constituted?—It would be necessary that those gentlemen should attend meetings, and it would probably be difficult for gentlemen to travel up from Scotland or from Ireland for such meetings, otherwise it might be desirable that they also should be represented.

11,798. What do you consider would be the principal duties of such a council?—To name commissioners for special inquiry, to discuss generally the amounts of the grants to be given to learned societies, and to advise the minister with regard to innovations proposed in Government departments. Take, for example, an invention of ordnance; if such a question, after a preliminary examination by the department concerned, were brought before the general body, it could there be discussed for the guidance of the Minister of Science, to ascertain whether such an innovation was based upon sound scientific principles, and what course of experiments should be pursued to lead to the best results. By referring it to the minister and having it discussed before such a council, a great deal of unnecessary expenditure might often be saved where, through the want of sufficient information, the experiments are conducted by the departments in a somewhat unscientific manner. Another duty of the council would be generally to direct the publication of the scientific information obtained through the different departments.

11,799. Do you consider that it would be the duty of such a council to initiate proposals on matters connected with science, or merely to give advice when asked for?—Only to give advice when asked for, but the departments should be held to communicate with the Minister all important questions brought before them, who, with the advice of the council, would direct inquiries to be instituted in many cases where the department would have simply rejected the proposal.

11,800. The council would be somewhat numerous if there were representatives of all those departments that you have enumerated?—There would be about 20.

11,801. Have you considered whether the members of the council should receive payment as such?—Not as such, because they would be heads of departments.

11,802. With the exception of the four additional members?—Yes, and I expect that they would decline to receive any payment.

11,803. Would it be desirable, in your opinion, that this council, or any scientific Government department, should undertake experimental research?—I think not; my impression is that scientific research should be left as free and open as possible. If gentlemen were specially instructed to make experimental research they would be, I consider, in a somewhat false position. They would be morally obliged to produce results in order to satisfy the public mind that they were doing their duty, and science or scientific research cannot be measured by such a standard of results. I consider that a man should always have some absolute duty to perform, some drudgery work, which might be made as light as possible; but my impression is that he would not be in a satisfactory position, either to himself or as regards the public, if discovery were his only duty.

11,804. What is your opinion as to the establishment of laboratories at the Government expense?—I would recommend the establishment of observatories but not of laboratories, for the same reason, that in laboratories unconnected with teaching, as have been proposed, using the public conveniences, and public money, there would be a necessity for results which would lead, to a certain extent, to something approaching charlatanism in the enunciation of those results; and, moreover, I consider that it might lead to disappointment in many, who would believe that they had an equal right with others to take advantage of such establishments.

11,805. Do you consider that laboratories are required in greater numbers, and better equipped then they are at present?—I think so, decidedly.

11,806. But still you would not remedy that defect by establishing Government laboratories?—Not by establishing Government laboratories, but by granting

C. W. Siemens, Esq., D.C.L., F.R.S.

12 June 1872.

Government aid towards the establishment of laboratories, and chiefly by the endowment of chairs.

11,807. Do you think that laboratories should chiefly exist in connexion with universities or other teaching institutions?—I think so, because we should always look to the coming generation, upon which the future depends chiefly; and a well appointed academical laboratory presents great opportunities for a student, under a great leader, to attain to eminence himself.

11,808. You consider that the country has derived great advantage from the scientific societies?—I believe that natural science has been cultivated in England, and maintained at a high level, in a great measure, by the exertions of the scientific societies. The Government has hitherto done hardly anything, and yet science has produced in England great results through its natural growth, and chiefly in connexion with societies.

11,809. Do you think that there has been less original research in this country than in some of the states on the Continent?—Perhaps so, because there are very few laboratories connected with the great teaching establishments of this country. A professor, well endowed and with light duties, has opportunities for research which no other person has, and on that account, perhaps, there has been more elaborate investigation in other countries. In Germany, the chief professors connected with the universities have not only a very well fitted laboratory, but they receive salaries relatively far beyond the salaries generally thought of in this country. First-rate German professors have near upon 1,000*l.* of assured income, or even more in some cases. They are, therefore, independent, and can afford to spend much time upon original research.

11,810. (*Dr. Sharpey.*) There may be several professors of the same subject in the same university, ordinary and extraordinary, *privat docenten* and so on?—Yes.

11,811. Do you know whether the *privat docenten* receive any remuneration from the State, or whether they trust entirely to their own teaching?—They generally trust to their own teaching.

11,812. But they are recognised as university officers?—Yes, but there are more than one salaried professor of the same science in the larger universities.

11,813. (*Chairman.*) Do you think it desirable that Government influence should be employed in stimulating private exertions in the interest of science?—In this country I think that private exertion will accomplish ends much more than is the case in other countries, and, therefore, it should be the policy of the Government to stimulate the elementary strength, and not to centralise too much where there is natural growth.

11,814. Can you point out any modes in which you think that Government influence of the kind could be advantageously exerted?—Through the learned societies, I think, that the Government could assist in their endeavour to develop science better than in any other way, and by the publication of information which individuals cannot obtain for themselves.

11,815. (*Professor Smith.*) I think that you have referred to the doctoral dissertations which are employed in Germany, and from which a candidate obtains his degree of doctor?—Yes, I incidentally mentioned them.

11,816. Those are frequently of great value, are they not?—Frequently they are very elaborate and original researches.

11,817. Do you see any reason why it should not be possible to introduce the same system in the English universities with regard to the higher degrees?—I see no reason why it could not be introduced, and I believe that it would be very advantageous in selecting for rewards men best capable of developing science independently.

11,818. Has there been no difficulty ever experienced in Germany with regard to the authorship of a dissertation; has there ever been any doubt raised as to whether it was really the candidate's own work?—He has to make a declaration to that effect, and I have not heard of any cases where a student had borrowed his feathers.

11,819. There is no reason to suppose that it works ill in that way?—I have not heard any complaints on that score.

11,820. With reference to national physical laboratories, it has been suggested to the Commission by several witnesses that such laboratories might be of use, not so much for the researches to be carried on officially in them, but as giving opportunities to private individuals for carrying on researches in them; has it occurred to you whether, in that point of view, they might be useful or not?—They might be useful in certain cases; but if the Government takes in hand such a thing, there must always be favouritism. It would be impossible to grant such facilities to all applicants, and it would be very difficult for the Government to use such discrimination. Any university or society could do so by granting facilities to men who had given promises of success by reading papers, or by fully explaining their objects in view; but for the Government to use such discretion would be impracticable, I think.

11,821. Then you think that there should be such laboratories that should be available to persons who could not afford, for instance, to have a physical laboratory of their own, but you do not think that such laboratories should be under the control of the Government, or should be Government institutions?—They should be exceptional cases altogether. If, in any existing laboratory, whether Government or otherwise, an instrument existed necessary for certain research, I think that facilities might be given occasionally to an applicant, but I am of opinion that it would not be desirable to establish what might be termed a national workshop of science.

11,822. (*Dr. Sharpey.*) Is there any such institution in Germany as a physical or other laboratory (apart from astronomical observatories), independent of an university, or an educational establishment?—I believe not. There are laboratories connected with Polytechnic or Mining schools, but still they are connected with teaching.

11,823. Has any difficulty been found in affording facilities in those laboratories to original inquirers who may not belong to the school?—It would not be difficult for any one to get access, for instance, to the laboratory of an University. If he entered his name, he would be allowed to go into the laboratory, and, under certain restrictions, imposed by the Professor, carry on his researches.

11,824. Are those laboratories, as established in Germany in connection with the universities and other educational institutions, quite sufficient for all the wants of science and of original investigation in science?—Whether more might be done by increasing their number I am not prepared to say, but still there seems to be no expressed want for additional laboratories.

11,825. At any rate you would not propose to establish laboratories on a different footing?—No.

11,826. (*Professor Stokes.*) You stated, I think, that you thought that fellowships would best be bestowed on those who showed a capacity for original investigation. Am I to understand that you think that a fellowship should be bestowed as a reward for work done or as a means of enabling a person to do work in the future?—I think both points might be met by a fellowship. A fellowship should not be granted except for original research, and it should be granted with the view of leading the recipient to farther researches in science.

11,827. If it were granted for original research already made, it would seem as if there were comparatively few cases in which the research would be of such a degree of importance that the fellowship might be awarded for that alone?—I think that the research for which the fellowship would be granted should not

C. W. Siemens, Esq., D.C.L., F.R.S.

12 June 1872.

be judged by its results, but rather by the capacity shown in the treatment of the subject.

11,828. Then I infer from what you say that you would mainly look on the fellowship as valuable because it affords the person on whom it is bestowed the means of doing good work in the future?—Yes.

11,829. If a fellowship were bestowed on that account, what means would you take of ascertaining whether work was done, or would you make the tenure of the fellowship dependent in any manner on the doing of work?—I think not. If a man has shown, by his original thought and capacity, that he is interested in science, I think it may safely be left entirely to himself whether he will go on with it in future.

11,830. Then I understand that you would trust partly to his feeling of honour and sense of duty, and partly to his love of the subject for what he might do in the future?—Quite so.

11,831. You have spoken, have you not, of granting rewards for original researches to be awarded by the learned societies?—Yes; but I think they should be exceptional cases entirely. I may mention also that pensions might be granted, perhaps, to men who had done good service in science, but only in exceptional cases.

11,832. Would you contemplate the learned societies recommending certain persons for such rewards or pensions, or that a limited sum should be placed at their disposal to expend in that manner?—I think it would be better for them to recommend to the Government to grant those rewards or pensions.

11,833. (*Mr. Samuelson.*) You spoke in terms of commendation of the activity in promoting science of the various learned societies in this country. Is there anything analogous to this, as to extent, in other countries with which you are acquainted; for instance, Germany, France, and Italy?—I believe that in France there are no independent scientific societies of any moment, because the Government pretty well monopolises science through its establishments. There is more activity in Germany, where there are associations for the promotion of special branches of science, but there is nothing at all comparable to the English societies for the promotion of branches of science.

11,834. Then, taking the two extremes, France on the one hand, where the Government does everything, and England on the other hand, where the Government is supposed to do little, if you had to choose between the two systems, which would you prefer?—The English system, certainly. At the same time, I think that the Government might facilitate those individual exertions by giving judicious aid.

11,835. And that aid you think should be given through the learned societies of established repute?—First, by collecting scientific information of general interest through the means at their command; secondly, by granting endowments to the teachers of science; and, thirdly, by granting aid to the societies.

11,836. Is it the case that in Germany aid is given to the societies by the Government?—I think not; but the societies are of very minor importance there. There are academies which are more or less under the Government, and they are maintained entirely by the Government, and the existence of those academies prevents the creation of such societies as the Royal Society in England. One instance that I can now call to mind of an independent society that has attainted to considerable rank for its beneficial results in the promotion of science is the Physikalische Gesellschaft of Berlin. They publish yearly reports on scientific progress, which are very complete and very useful.

11,837. Do they receive any aid from the Government, either towards the cost of their publications or otherwise?—I believe they do not.

11,838. You spoke of the aid which the Government might render to science by collecting information and placing it at the disposal of the learned societies and scientific men; is that carried out to a greater extent in Germany than in this country?—Perhaps not. The Government does a great deal through the aid given to academies, the universities, and schools. The Government also publishes statistics, but a great deal more might be done, without doubt, in that direction for the dissemination of science.

11,839. Would you state what is the constitution of the Academy?—They are an assembly of savans paid by the State for the promotion of science, but there are no special duties connected with the appointment.

11,840. Are they responsible to any Government department?—I think not; but I speak only from general information.

11,841. So far as you are aware, is there anything in Germany or in France analogous to the council or board which you recommend should be established in this country?—I believe not. I should have mentioned that there are other societies besides the Physikalische Gesellschaft in Germany which have done good work; there are the Chemical Society of Berlin, the Naturforscher Verein, Eisenbahn Verein, and other special societies which have done good work.

11,842. With the exception of the liberal endowment of professorships at Universities, is there any other way in which the Government of Germany has done more for science than the Government of this country?—The Government of this country has done very little for the advancement of science until very lately, whereas the continental Governments have spent a great deal for teaching the higher branches of science, and for the culture of those higher branches at the universities.

11,843. But, in point of fact, the action of the Government of Germany in the promotion of science has been mainly, or almost entirely, has it not, through the support given to the universities?—Yes; and through the establishment of Polytechnic and Mining Schools.

11,844. That is, so far as teaching is concerned?—Yes; but also by the establishment of observatories.

11,845. Has more been done in the way of establishing observatories abroad than in this country; say, in Germany and in Russia?—I think not.

11,846. Your opinion was that the Government should not direct scientific research, but I think I understood you to say that it was desirable that they should direct inquiries to be made in reference to subjects of direct national importance?—Yes.

11,847. And those you think should be carried out chiefly by commissions in each case appointed for the purpose?—Yes; by commissions appointed for the purpose. I think that there should always be a direct practical object in view.

11,848. Do you think that the work of those commissions has, in the majority of cases, been well done, where such commissions have been appointed in the past?—I am inclined to think they might have done better in some cases.

11,849. Are you acquainted with the labours of the Coal Commission?—Generally I am.

11,850. You are not prepared to say that in all cases those commissions have been very successful in their results?—I think that they would be more useful if they were connected with a scientific organisation such as I have sketched.

11,851. If those inquiries were directed by a Government council of the nature of the one which you have sketched, do you think that they would be more likely to be successful than if they were left to make their investigations in a more independent way?—I think I would as much as possible leave investigations in the hands of individuals. I would make inquiries through committees or commissions, because they have the means at their disposal for collecting information which private individuals have not.

11,852. Taking the case of the Coal Commission, of which we have spoken, would it not have been a fair subject of inquiry for them to ascertain by borings the existence or otherwise of coal at a great depth?—Precisely so. If they had funds at their disposal, it

C. W. Siemens, Esq., D.C.L., F.R.S.

12 June 1872.

would have been a very legitimate undertaking in their hands to ascertain by borings and other tests how far the coal-fields extended.

11,853. Do you think that that would have been a proper application of the public money?—Quite so. I think that in a case where important information is required which can only be obtained by means of considerable expenditure, the Government might and should supply the means.

11,854. Do you think that the accurate ascertainment of the increase of the temperature of the earth's crust by increased depth would have been a proper subject for investigation by such a commission at the public expense?—Inasmuch as it bears upon the question of coal-getting, certainly, but not beyond that limit. I think that to make elaborate investigations into that question, irrespective of any immediate practical object, would probably have been beyond their proper sphere of action.

11,855. You think that investigations at the Government expense should have a direct practical bearing, and should be such as are, for some reason or other, beyond the reach of individuals?—Yes, and to lead to a definite result.

11,856. Have you considered carefully the question of the dimensions, so far as numbers go, of the council which you think should advise the minister in reference to scientific questions?—This council I think should be simply a consultative body, and should consist of the heads of departments, because unless the council had an immediate connection with the departments they would not understand the needs of those departments, and they would very likely go wrong in supposing that certain things were desirable and attainable, in the absence of precise information as to other considerations which would weigh with the department.

11,857. Then you would look upon the main use of this council as residing in what you have called the juxtaposition of the heads of departments?—Yes.

11,858. Who should be the head of the council?—A minister. I think that there should be a Minister of science and education, which would constitute an important department, too important to be under different other departments.

11,859. Do you think it is desirable that the head of it should be moveable, in accordance with political contingencies, rather than a permanent official responsible to a minister?—This would require very careful consideration, but my decided impression is that it should be political, because, as the presiding head, the minister would not be required to be a man of science himself, he would act upon the advice of the council, and I think that it would work better if he were responsible to the public.

11,860. You think that a political officer of sufficient knowledge could be readily found to preside over such a council, or rather that there would be the choice of such a political officer out of either of the two great parties?—Yes; I think that there are political men of highly cultivated minds, or even with a great knowledge of science who would be quite capable of taking such a position.

11,861. Having a sufficient general knowledge of science to be able to preside over such a department?—Yes.

11,862. (*Chairman.*) One of your recommendations was that the Government should encourage scientific education by the liberal endowment of academical chairs; are you able to state the scale on which you consider such endowments should be made? What do you think should be the salaries of the professors?—I think that there should be very liberal salaries paid; much higher than what is usual in this country.

11,863. I suppose that one may consider 500*l.* or 600*l.* a year a liberal salary at present?—Yes; but I think that double that amount would be more proper, certain fees being included. Many professors connected with the freer institutions and colleges have to carry on professional work, and that must, to a great extent, unfit them for original research.

11,864. I think that almost the only new establishments which you recommend are certain physical observatories?—Yes.

11,865. What would be the principal object of such observatories?—For the purpose of magnetic observations, solar observations, and other general inquiries into physical phenomena.

11,866. Do you contemplate the establishment of more than one such observatory?—Probably more than one would be desirable.

11,867. Do you contemplate the establishment of any such observatories in any of the colonial possessions of the country?—Yes, I think so.

11,868. Speaking generally, would they be costly establishments to found?—Not very costly, not so costly as astronomical observatories.

11,869. Would not the council of which you recommend the establishment be composed almost entirely of official elements?—Yes, the object being to bring the different departments together under one head, where the experience and the knowledge of all might be made available for the advancement of science in every branch.

11,870. You would place each of the departments under a responsible head. Are there several instances, at present, in which those departments which you have enumerated are not under responsible heads?—In most cases where the departments exist as scientific departments, they are under responsible heads; but what I wished to say was, that I would not take away their individual responsibilities by substituting a collective one.

11,871. Are there any officers at present appointed by the Government that would naturally represent certain large departments; for instance, gunnery, fortification, and the telegraphic departments?—Such heads exist in a measure, but are too much mixed up with other public departments. In the case of the telegraphic department, there is a chief to take charge of the civil telegraphs, a gentleman connected with the General Post Office, Mr. Scudamore, and the military telegraphy is under certain officers; but those officers are not responsible heads in the sense in which I would make them so. The one is under the Postmaster-General, and the others are under the War Office, but Telegraphy is not raised at present into the dignity of an independent scientific department.

11,872. Then the organisation of those departments would require some changes, would they not, in several instances?—Yes.

11,873. Are there any other points upon which we have not sufficiently elicited your opinion, or on which you could make additions to your evidence?—I think not.

The witness withdrew.

Maj.-Gen. R. Strachey, F.R.S.

MAJOR-GENERAL RICHARD STRACHEY, R.E., F.R.S., examined.

11,874. (*Chairman.*) I believe you hold an appointment connected with the Government of India?—Yes; I am at present employed in the India Office, and I have been for many years under the Government of India in the Public Works Department.

11,875. Have you considered how the aid given by the Government to the advancement of science may be made more effectual than at present?—I have been invited to give my opinion upon the subject generally, and I have been thinking it over, and, applying the experience which I have acquired in my past life, I will offer such suggestions as seem to me to be useful. And, first, I think it is necessary, although, perhaps, it may appear a little pedantic, to say that I understand the intention is to refer specially to physical science; for science is a very broad term, and there is a great deal of other knowledge that deserves the name of science, which I apprehend hardly comes within the scope of the inquiries made by this Commission, such as moral science, mental science, and economic science. The matter which I am proposing to discuss is to be considered, I think, first in relation to the probable beneficial effects to be obtained in the public administration through the due appreciation and the application of scientific knowledge. That is one branch of the inquiry, and another is what are the measures which may best be taken for increasing the facilities which the community at large has for acquiring scientific knowledge, and the means of extending that knowledge. A question which arises at the outset, and it is an extremely difficult one to answer, is that of the general utility of Government interference in promoting scientific inquiry. Opinions no doubt will be divided upon such a subject, and, from the actual results that have been accomplished in England, a great deal may be said in favour of the Government doing nothing; but because England, without any assistance from the Government, has done so much, it seems to me that it would be altogether a false inference to deny that, if the Government had assisted the progress of science in a rational way, we should not have done a great deal more.

The essential thing, as it appears to me, to be aimed at, in any action that the Government can take in relation to the promotion of science, is an improved system under which the responsible administrators of the public departments shall be better advised on scientific questions, and shall be placed in more satisfactory relation with the actual heads of scientific institutions which are supported by the State, or of scientific institutions which the State may, under any circumstances, be called upon to assist, whether they are actually supported in a money point of view or not by the State. In going on to discuss the more precise way in which any such result shall be arrived at, the first thing that it is necessary to consider is what are the actual existing forms under which the public administration of the country now goes on; for any proposal, to be in a practical form, must necessarily mould itself to the existing institutions of the country. Consequently, the first conclusion that I arrive at is, that all questions relating to scientific matters that arise in the operations of the Government should be dealt with by one of the chief ministers of the Crown, and the officer at the head of the Education Department seems to be the most suitable of such officers. It has been, I know, suggested by some persons that it would be better if there were a separate department for science. That I venture to doubt. I think there would be considerable risk, if there were a separate scientific department, of its being looked upon by a great many persons as what they would call unpractical. Further, I think that a minister who participates in the general administration of the country, if he were actively disposed to promote the progress of science, would be in a far better position to do so than a person who merely had the charge of abstract duties, or duties that were to a great extent abstract.

Supposing, then, that such a general basis were accepted, and the whole of the scientific business of the administration were placed under some single department, which I may call the department of education and science, the next thing to be done in improving matters would be to bring under that department the administration of all existing public scientific institutions of every description; I mean institutions which are specifically scientific. I do not mean at all such departments, for instance, as the constructive department of the navy, or the manufacturing departments of the army, or the telegraph department. I do not think that to subordinate those to such a central scientific department would be at all desirable or practicable.

11,876. You would place the Greenwich Observatory under this department, would you not?—Yes, all the museums would naturally fall under such a department, and Kew Gardens, and I should say the Geological Survey, and the Ordnance Survey; I should doubt regarding Naval Surveys on account of their speciality. But I do not at all pretend, on the spur of the moment, to lay down any hard and fast line, according to which I would say that any branch of public business should be placed under the minister of education, and that any other should not. My general meaning is that those offices or branches of business, the character of which is mainly scientific, should fall under the new department, and those which are essentially administrative should remain under their proper administrative heads.

I would add that, under such an education and science department, there would be a natural division of the duties, which would probably lead to the appointment of some permanent officer in the position of an under secretary of state, who would have specific charge of the scientific duties of the department as distinguished from the educational duties, which constitute a distinct branch of administrative work. I also think that through a department of that sort a very useful result might be obtained in the cause of general scientific education, by so organizing it that the persons employed in it might be required to have specific scientific knowledge, and should not be accepted as for an ordinary civil department on a mere pass examination under the Civil Service Commission. By suitable arrangement of salaries, and so forth, a good deal might be done towards opening an administrative career to scientific men, which would be ultimately of the very greatest use to the public civil service by introducing into it an amount of precise scientific knowledge which at the present time does not exist there.

11,877. The permanent under secretary of the department you would consider ought to possess scientific qualifications?—Yes, I should say so.

11,878. And not only the permanent Under Secretary, but other persons employed in the office?—Yes, the principal officers in the proposed scientific branch of the department should be, by their scientific qualifications, capable of disposing of the ordinary current business under their charge. One might say, for instance, that there would be some officers to discharge the business relating to museums, one or two of whom should be required to have some precise knowledge of natural history, and in the same way that an officer in charge of the department which looked after the observatories might be required to have some specific and precise mathematical knowledge, and so forth.

The whole of what I would call the material requirements of the scientific institutions maintained by Government, everything in the shape of new buildings and repairs, or the maintenance of the buildings, might with great advantage and propriety remain as at present under the Chief Commissioner of Works; but I consider that the Office of Works is a body utterly unfitted to control the real administration of those institutions. I look upon it as an outrage to common sense that the Office of Works, for instance, should have the control of Kew Gardens, *quoad* a botanical institution; and equally ridiculous that it should have the control of the Trigonometrical Cadastral Survey of England, which I believe it has.

Next it seems to me that, under such an organisation as I have alluded to, the chief of each separate institution, whether it were an observatory, a museum, a botanical garden, or whatever it might be, should be directly responsible to the head of the science department for his administration, and through that department financially responsible to the Treasury. I do not propose to make any specific suggestions as to the precise way in which observatories, museums, and so forth, should be managed. I am not in a position to give an opinion upon the details of such subjects; all that I would insist on is, that whoever is the immediate executive authority in charge of any museum, for instance, or any such congeries of museums as the British Museum, or any other institution, there should be a specific and direct responsibility placed on that person to the science department, and that operations

Maj.-Gen. R. Strachey, F.R.S.

12 June 1872.

should not be carried on, as I understand they are in the case of the British Museum, in a sort of bastard way, with more or less direct communication with Parliament. The Trustees of the British Museum are not specifically under a minister, which, I think, is radically wrong.

11,879. (*Professor Huxley.*) I think it is one Trustee who happens to be in Parliament, who always moves the estimates?—Yes, I think so; and that no really efficient public administration can go on unless there is specific ministerial responsibility. I pass on to the question of how a department of science could exercise an intelligent and beneficial control over the action of such heads of institutions as I have been speaking of. It seems to me manifest that, in the nature of the case, it would be necessary for the officers of the department of science to seek outside their own body for advice regarding the detailed management of such institutions, and equally that it would become necessary for such a department to seek for advice outside its own body as regards questions that came before it regarding the advancement of science generally in other ways. For, unfortunately, it happens that English people now can hardly be said to receive a scientific education at all, and the persons who are employed in the public administration are certainly as a class not amongst those who have anything deserving the name of scientific education; therefore, for a long time to come, it is not to be expected that the members of the Government, or their chief subordinates, will have any such general knowledge of science as would enable them at all satisfactorily to deal with the scientific questions which come before them. Therefore, I conclude that it is absolutely essential for the Government, under any circumstances, to get advice from outside; and then comes the question as to how this advice is to be got. If there is no recognised and regularly organised body whose business it is to give advice to the Government on such subjects, then the only thing that a minister can do is to get his information from unrecognised and irresponsible authorities, persons whose opinions, perhaps, may be very valuable, but still persons of whom the public never can have any cognizance; and private advice given in that way seems to me given in the worst possible form. If, then, that form of advice is bad, how can you obtain advice of proper intrinsic value on the multifarious subjects on which it is certain to be needed by an administration really striving to advance science to the utmost, and how can you secure its being given under a sufficient sense of reponsibility, and in such a way as to carry the greatest weight possible to the mind of the minister who is expected to act upon it? And here I would repeat that any specific proposal to give effect to such an idea must be made to fit into the general form of the administration; and I, therefore, consider that the best course would be to adopt the proposal that has been made by many persons, that there shall be some sort of council constituted to advise the responsible Government department as to its proceedings in connection with science.

The first consideration that arises in my mind is, that, if such a body is to act practically and usefully, it must be possessed of the confidence of the minister. If the body, however intrinsically valuable its advice may be, has not the confidence of the minister, practically speaking, their advice will be a dead letter, and no result can come from it. What all persons who desire to see science advanced have to aim at, and have to strive to attain, is a practically useful result; and if any scheme, whatever other advantages it may appear to have, does not carry with it the probability of being practically useful, it seems to me that it is quite unnecessary to discuss it further on those grounds alone. In order to obtain a body which shall possess such weight with the minister that its recommendations shall carry conviction, I think that, at all events, until the Government and the public have been educated up to what I should call a proper respect for science and the opinion of scientific men, this advising body should be nominated by the Government; and that it should not be either elected from existing scientific bodies or educational establishments, nor selected exclusively or mainly from them as has been proposed by some persons. I think that the only way to lead a Government in the proper course which they should pursue in relation to science is to give them advisers whom they have agreed to accept, and whom they are, therefore, forced to admit as trustworthy and satisfactory guides. The only way in which that sort of relation between them can be established, I think, is to put a specific responsibility upon the Government to nominate. I think, too, that there would be, under such an arrangement, an action of a similar character in the other direction, and that a person who was specifically nominated by the Government to perform those particular duties would have a much stricter reponsibility put upon him, so to act and so to advise the Government as to produce satisfactory results, than if he were merely developed, so to speak, by the operation of some external body.

11,880. (*Mr. Samuelson.*) You would object, as I understand, to *ex-officio* members?—I think so.

11,881. (*Chairman.*) Would you propose that the members of the council should be liable to dismissal at the pleasure of the minister; would not that almost follow as a matter of course if they are necessarily to possess his confidence?—I would not go quite so far as that. I think, practically speaking, it would suffice and be better, in my point of view, to have the number of the council not very rigidly fixed, to make the nominations not for a very long period of time, and to give the minister an opportunity, in that way, at any time that he thought desirable to put in any particular person; if, when the time for renewal came, he was not satisfied with any person who went out in the ordinary course of events, he would have an opportunity of putting somebody else in. But I think that, considering the duties to be performed, the character of the persons who practically would be nominated to such a council would be such as to make the contingency of the minister desiring to turn any of them out a very remote one indeed.

11,882. Even in the case of a change of ministry?—I think so. I think that it is not likely that a minister would wish to dismiss a person on political grounds from a purely scientific body. He might desire to add some one, but dismissal would be an extremely strong measure to take where persons are not selected in any sense on account of their political views, but merely on account of their probable fitness. I think that an illustration of the working of a system of that sort may be found in the circumstance, that a permanent Under Secretary of State is not a political partizan. Whatever his political opinions are, as a rule, he remains a very useful member of the administration under all political changes, and he is generally accepted as such. I would further say that I think it is not desirable to constitute such a body too rigorously of what you may call merely scientific men. I think that in order to put propositions in a practical form and in an acceptable form before the minister, it is desirable that there should be persons in the advising body who have a certain amount of administrative experience. Also, I think that, as society is constituted now, there should be in it persons of what is commonly called superior social position, such persons having certain advantages in getting access to the minister and in guiding public opinion, which others have not. What should be aimed at, in short, is a practically useful body rather than an eminently theoretical scientific body; and I should say that a body not differing materially from this present Commission has the sort of constitution which would secure the best exercise of the influence which I conceive that this advising body should exercise. I think that all that would be necessary to enable it to do all that could possibly be required of it, would be to entrust it with suitable power, where the occasion required, for making specific references, or for calling into its councils persons specially

Maj.-Gen. R. Strachey, F.R.S.

12 June 1872.

qualified to advise it, who were not permanently upon the Commission. I think that an arrangement of that sort could be carried out without any particular difficulty.

11,883. You think that the body should not be very numerous?—I think not.

11,884. Would you think nine a sufficient number?—I should think so. There are nine members upon this Commission, and I dare say that the whole nine do not always attend. I say, distinctly, that my experience in life is, that if you have a large body, consultation becomes extremely difficult; also, I think that the larger the body the more divided is the sense of responsibility, and, also, under certain circumstances, that the larger the body the less is the weight that is attached to its opinion. I would not say that absolutely, but where a body is constituted to advise on a great number of miscellaneous subjects, and you attempt to represent every conceivable form of science in such a body, each special branch of knowledge would be represented by some one individual, so that the result would be that its decisions would eventually rest, or appear to rest, on the opinion of an individual, whom it would be easy to pick out as virtually representing the basis of any opinion given by the Commission. I think that any such result as that is plainly more undesirable than desirable.

Further, as to its method of working, I should consider that a commission so formed should, by degrees, proceed to take up and consider the system under which all existing scientific institutions supported by the State are carried on, and to propose the revision of the constitutions of the managing bodies, as far as any revision was necessary to bring into a proper and co-ordinate system the method under which such institutions were managed or inspected, and under which advice was given as to the manner in which they should be conducted; that they would suggest in some cases, for instance, the formation of bodies of visitors, who would give advice from time to time; and having received from the Commission such proposals or suggestions, it would be the duty of the administrative department of the minister of science to give effect to them, so far as on further consideration he thought they were desirable, and the Commission would in this way become, so to speak, part of the constitution of the scientific administration. In a similar manner such a commission would take up and consider and mature proposals for the creation of new institutions, which have been talked of as desirable for the advancement of science, such as physical observatories or physiological observatories or laboratories, or whatever they may be termed; and by dealing with such matters by degrees, and getting the best advice that was possible (it would be perfectly possible for the commission to get the advice of anybody whose opinion was worth having), schemes in a perfectly tangible, practical, and definite form could be put before the government department, with much more probability of attention being given to them, than to any mere sketch, open to all sorts of objections on account of its indefinite nature, however valuable the suggestions it embodied really were.

I may add that I have no doubt of the importance of founding such new institutions as those I just spoke of, and of the necessity for their being supported by the Government if they are to come into existence at all. I can readily understand that persons exclusively interested in any special branch of science, which now has at its command all needful appliances for observation in that particular direction, say, for instance, that class of astronomers which is already amply supplied with what their science requires, may not feel the importance of giving similar material aid to other branches of science, of which they have, perhaps, comparatively little knowledge, and in which they take comparatively little interest. Such persons, however, would be certain to exclaim strongly against any diminution of their own existing advantages, and the feeling which would lead to this is a positive testimony in support of the claims of those scientific inquirers who ask for similar aid in their own behalf.

11,885. Would you propose that this council should initiate proposals itself, as well as consider subjects on which its advice was asked?—Yes, I think so. I think that the greatest freedom of action should be given to the council; that it should be in a position to make any representation that it thought desirable to the minister on the subject of science. Indeed, it would be one of the great utilities of such a body, that it would have access to the responsible minister in the time of need. I think that what has occurred in connection with the last two total eclipses of the sun has shown it to be extremely desirable that there shall be some scientific organisation which has a right to present itself to a minister of the Crown and to be heard; and that the institution of a body of this sort would, at the same time that it removed all appearance of undue pressure or importunity, bring about that result in a natural and healthy way. I think, also, that under such a commission, proceeding in the sort of way that I have suggested, and having obtained the necessary sanction from the minister, and the necessary authority for any expenditure that was to be incurred, investigations might be taken up on various subjects, either merely abstract investigations for the advancement of science, or specific investigations required for the purposes of any of the public departments. That is a general sketch of the functions and duties which I should conceive would devolve on such a body.

11,886. (*Professor Huxley.*) Would such a body as you are proposing supersede the Government Grant Committee?—Yes, certainly; and I would take the opportunity of saying that it is a question that is open, and which I believe has been discussed, whether the council, for instance, of the Royal Society, with or without any addition, might not be made to perform satisfactorily some or all of the functions which it has been suggested should devolve upon this commission. But I think not. And the principal reason that I have for thinking that such a body as the council of the Royal Society is not suitable for the purpose is, that it cannot have that specific responsibility put upon it which should be put upon a body such as I have spoken of, and that it is got together for totally different purposes and objects. The council of the Royal Society has to manage the business of the Royal Society, and is not at all selected to advise the Government on matters connected with the advancement of science, or the application of science in the operations of the public departments.

11,887. (*Dr. Sharpey.*) And one-half of their number is changed ever year?—Yes.

11,888. (*Mr. Samuelson.*) You could not make the minister responsible for the action of the council of the Royal Society or of its committee?—Not at all.

11,889. Because the nomination of the council and of the committee is by a body of constituents over whom the minister has no control?—Quite so; the minister would have a perfect right to repudiate any scheme which they put forward or any advice they gave; I mean that he would be justified in doing so on the ground that he was not responsible for their selection.

Perhaps I may go on to say that, as regards the number of this proposed body, and I am happy to say that almost all scientific authorities seem to coincide in one respect, that is to say, that there shall be some such body, some of the proposals suggest a very numerous body, a body so large that all questions likely to come before it might be disposed of by the help of its own members. Now I think that, practically, supposing that you had an arrangement of that sort, it would necessarily happen that you would entrust the initiation of business to some selected sub-committee. If you had a body of 30 or 40, or 50 members, it would be perfectly impossible to throw the whole of the business into their hands in a heap; it could not be done; either its distribution must be

Maj.-Gen. R. Strachey, F.R.S.

12 June 1872.

put specifically upon some individual or secretary, which I do not think would be desirable, or you must have a managing sub-committee, which would come very much to the same organisation that I have proposed, only arranged in a slightly different way; but, generally, the results would be very much the same. Another course which might be suggested is, whether, supposing we have a scientific Under Secretary of State, he could not perform the duties proposed to be discharged by the commission; but I think that arrangement would be open to the same sort of objection that there would be to referring all questions first to the secretary or to some principal officer of a large commission, namely, that he would not have, and could not in the nature of things have, the breadth of knowledge necessary for giving advice on the multifarious subjects which would come before him; and it is really to supplement his incapacity, because there is no single human being that could have the necessary knowledge, that it is proposed to create this advising body. I think there is a further great advantage in having a body with a certain breadth, so to speak, to it, and that is, that the several physical sciences are so interwoven with one another, that it is extremely desirable, in considering any scheme pertaining to any special branch of science, to have the opinions of persons who are acquainted with other branches of science. You can never tell precisely, without careful inquiry, whether the advancement of any particular branch of science may not, collaterally or otherwise, be affected by measures taken, with some other intention, on any given proposal.

A question which I suppose it is necessary to discuss, or at any rate to refer to, is that of remuneration, and my own impression is that, at all events to begin with, it is not expedient to raise the question of salaries at all in relation to this particular body. The whole of the operations of this consultative council would be altogether tentative, and it would be extremely difficult to say, off-hand, what it would have to do, or what amount of time it would have to devote to carrying out its duties. I think that, under those circumstances, it would be better to place the commission in the position of the unpaid Royal Commissions, on the understanding that, if the duties were found to be more onerous than I anticipate, some system should be adopted under which fees should be paid for actual attendance, or under certain circumstances, as, I believe, is the case in some similarly organised bodies. As to persons not in the commission, who are consulted by it, it is not reasonable to expect that scientific men should give their time gratuitously for the performance of public duty, any more than anybody else. There is no doubt that, within certain limits, it is perfectly proper and right that they should be remunerated. I think that what is wanted, in that respect, might be secured by an arrangement under which a reasonable remuneration would be given to scientific men whose time was occupied on inquiries instituted by the commission, or in the preparation of reports for the commission, or even in coming before the commission to give evidence or advice; and it seems to me that such a system as that would probably meet the question of proper remuneration of the scientific men who gave up their time for this sort of purpose, better than creating salaries and creating a salaried body, which I feel satisfied would meet with the very greatest opposition, so that the probability is, that the mere suggestion that any such body was a necessary part of the scheme would prevent its being taken into consideration altogether.

It should be understood that the advice which the commission gave to the minister on any question that was remitted to them for their opinion should, as a rule, be made public, and that they would be pledged specifically to the responsibility of giving that advice. No doubt there are certain cases in which it would not be expedient or decorous to publish their advice, but that would be a matter of discretion which must rest with the minister, and I think may reasonably be left to him. There would be cases, for instance, in which the minister might ask a question as to the relative qualifications of two scientific men for some post, and the commissioners would give an opinion and their reasons for that opinion, but it would not be right that the grounds on which they formed it should be made public; still, as a rule, the more complete the responsibility put upon everybody connected with the commission for the opinion that he gave on any subject that came before it, the better would it be.

There is another point of some importance; I do not think that, under any circumstances, such a body ought to have the power of the purse. I do not think it would be at all desirable to make over money to it to be spent on scientific objects. I do not think it desirable, for instance, to make over a lump sum in the way that it is made over to the Royal Society for distribution. Such a body, from its constitution, has not that sort of inducement to strict economy that is absolutely necessary in the public administration. There is necessarily in a large body of men who have nothing to do with public administration, a tendency to be a little lavish in their proposals; it is not precisely their own money that they are spending, and they do not see the difficulty in getting it. I think that it is not at all desirable that any change of system should take place in the direction of spending of money through them—I mean any change from the existing system, which places the responsibility for all public expenditure on the minister. Of course, if a specific vote were taken in Parliament for a specific object to be applied under the commission, that would be a different thing, but even then I think that the precise application of the public money should take place under the control of the minister, and that the commission should merely act as his disbursing agents.

11,890. (*Mr. Samuelson.*) Would not you wish such a commission to prepare estimates with reference to expenditure of that kind?—Certainly. Estimates of any expenditure that they proposed. They should place any proposals that they had to make in a definite form before the minister, but I would not hand over any lump sum to them as is done now in the case of the Royal Society. I understand that the Treasury give a thousand pounds a year to the Royal Society, to spend in their own way on scientific objects. I think myself that this system is essentially vicious; to make a homely comparison, it is as though I desired to absolve myself from all responsibility in connection with the suffering and poorer class of the community, by giving the first beggar I met sixpence. The Chancellor of the Exchequer hands over a thousand pounds to the Royal Society, and thinks he has done all that is necessary for the promotion of science.

I think it would be a mistake to attempt to place upon any such body as this the general control or regulation of the scientific advice which it is necessary for the Government administrative departments to receive. I think that the idea of placing such matters as the construction of ships for the Navy, or the form of guns, or of small arms, or of projectiles, and so forth, upon a body of this sort is altogether a mistake; that is not a function that should be put upon such a body; it is not really what is wanted. The departments of the Government that have to carry out those particular duties are responsible for possessing the necessary knowledge; for instance, the department that builds ships has within its own body all the necessary means of acquiring the information requisite for designing proper ships and for building proper ships, or, at all events, if it has not, it ought to have; and if there is a defect in the organisation of those bodies, they ought to remedy the defect themselves; they ought to introduce amongst their officers proper people. But there is one way, no doubt, in which a body like the proposed commission would be extremely useful, and that is in supporting the responsible heads of those departments of the Government

Maj.-Gen. R. Strachey, F.R.S.

12 June 1872.

against foolish pressure brought upon them by ignorant persons in the Government or from without. Take the case of the "Captain," which has been alluded to in other evidence. There is not the slightest reason to doubt that the responsible officers in the Controller's Department knew perfectly well that the "Captain" was not a safe ship, but their opinion was overridden, and if Admiral Robinson and Mr. Reed had had a body of this sort to refer to, if they could have challenged the Admiralty board to take a scientific opinion from this body as to whether their views were right or wrong, great good would have resulted; but that the Admiralty, whenever a design for a ship was made, or any new scheme was brought forward for consideration as to its applicability to the public service, should send it to a board of this description, I look upon as quite out of the question. The Admiralty would not do it, and no public department would ever think of doing such a thing.

One branch of the duties which such a commission could most usefully take up would probably be in connection with the administration of the colonies and India. The administration in the colonies, and particularly in India, goes on under very different circumstances from what the administration does here. I need not say much about the colonies, except that, generally speaking, their condition is analogous to that of India, but I will refer more precisely to India, which I know much better. In India, in relation to all scientific subjects, the Government of that country is placed in a position of great difficulty. It is extremely difficult to find scientific men at all, and those that are to be got in the country are, as a rule, extremely overworked. The distances are very great, and, with one thing and another, it is extremely difficult to get scientific opinions; but the chief difficulty is the absolute absence of men of science—that they do not exist in India. Here in London, which is at the centre of the civilised world, you have whatever means there are of acquiring knowledge on all subjects connected with science, and the greatest facilities exist for investigating any subject or obtaining good advice on any subject of this description, and if some central body existed here to which reference could be made from India or elsewhere for advice, or information, I have not the least doubt that it would be extremely useful. I am able to say positively, from my own experience of what I have seen of the public administration in India, that that is the case. I could specify instances which have arisen under my own knowledge, within the last few years, in which, if such a department or such an organisation had existed, the Government of India certainly would have requested that reference might be made to it for advice, or assistance in obtaining information. You must remember that in India the Government is the originator of almost every improvement, and, so far as those improvements involve operations which ought to be conducted with a proper appreciation of scientific principles, it is most important that the light of science should as far as possible be obtained to assist the Government in the attempts that they make, and I believe not vainly, to improve the country. I will just run through a few of the points which I think are worthy of notice in this point of view; I mean the subjects on which the Government of India might, during the last few years, have consulted a body of this description on matters arising in connection with the administration. Some years ago the Government instituted a Forest Department. It was discovered that the forests of India had almost ceased to exist; that they had, so far as the practically accessible parts of them were concerned, been all but destroyed. Timber is an useful, not to say a necessary, thing, and it was determined that an attempt should be made to resuscitate the forests, to take care of them in future so far as they existed, and recreate them. We had no experience of the systematic administration of forests in India, and we sought for it elsewhere. Now this was a matter on which the Government of India would gladly have sought the assistance of any scientific organisation which existed in London, to obtain for them the best information that could be got on the subject of forest administration. It so happened that we had an excellent officer in charge of the forests in Burmah, who, being a German, had received an education which specially qualified him for his duties, and had facilities for communicating with the heads of the German forest administration, who again were cognizant of the system in France. By his help, chiefly, we devised a system which is now in operation, but the devising of that scheme and the setting of it on foot would no doubt have been greatly facilitated if we had had some scientific nucleus of opinion to fall back upon here; because it was not without a great deal of opposition on the part of the general administration that the idea was accepted at all that there should be any such attempt made to preserve or to improve the forests. Again, during the last few years there has been a development of tea planting, which was originated by government action, and which involves the application of quasi-scientific principles. There is the production of quinine, which is now in its infancy, and still requires a good deal of watching and a good deal of consideration: there is not the smallest question at all that the cultivation would be greatly improved, and the prospects of success greatly enhanced, if more complete scientific light were thrown upon the whole question of the production of alkaloids in the bark, and so forth, and the way of obtaining them in a commercial form. Such knowledge the government has endeavoured to apply to its operations. Then I suppose India, of all countries in the world, is, from its climate, the best suited for the production of tobacco, or as well suited as any one country in the world. Up to the present time, however, hardly an ounce of superior tobacco has ever been exported from India. An attempt was lately made to get information as to the system under which tobacco is best grown, and what were the peculiarities of soil and manufacture, and so forth, which led to the production of good tobacco, and we are still making inquiries; in this case, too, had some central scientific advising body existed, we might have derived great advantage from it. Then there are various fibres and gums which are produced largely in India, on which scientific information would be very valuable. I will mention another instance. The Government in India is the great manufacturer of the salt of the country; it had occasion to send to England for two persons to assist in improving the manufacture of salt in Northern India. They were sent out; one of them again was a German, who, I believe, had all the necessary scientific knowledge on the subject of salt-making, and, so far as I know, he is a very useful person and is still employed. The other person who was sent out came from Cheshire, and when he arrived he wanted to know what was expected of him, what were the duties that he would have to perform. It having been explained to him that he had to make salt out of the natural brine of the country, he said, "I cannot do that, my duties are the preparation of "Cheshire salt, and giving it that beautiful white "appearance which makes it suitable for the English "market. That is my speciality, and I can do that "perfectly, but I cannot do anything else," and he added, "The best thing you can do is to send me "back again," which was accordingly done. Here is another illustration of the fact that the Government is in need of a scientific or a quasi-scientific agency to assist it in ascertaining precisely what are its it wants, and how to supply them effectually.

11,891. (*Chairman.*) Do you not consider that, for Indian questions, a certain amount of local knowledge of India would be, if not absolutely necessary, a very great additional advantage?—It would be certainly extremely desirable, and under such a commission as I speak of, if there were nobody in it who knew anything personally about India, there would always be an opportunity of inviting the co-operation and of getting the opinion of persons who had that know-

Maj.-Gen. R. Strachey, F.R.S.

12 June 1872.

ledge. A commission so constituted would have not the least difficulty in ascertaining who are the proper people to ask, and from whom to get information. One of the last measures relating to India, in which I personally have been considerably interested, is the introduction of an uniform system of weights and measures for India. I think that on a subject of that sort the advice of such a body would have been extremely useful. The general disposition of the Indian administration in England is to prevent anything being done in regard to the weights and measures of India, which I do not think is quite the best thing. Considering that there is no such thing as a weight or measure defined by law in any part of India, it does not appear to me, at first sight, to be an excellent state of things.

11,892. (*Mr. Samuelson.*) I thought that you had adopted the metric system?—I introduced a bill for that purpose, which was passed by the Legislative Council in India without a dissentient vote, but it was vetoed by the Secretary of State. With the approval of the Governor-General and his council, this act was passed two years ago with the intention of introducing the metrical system in a tentative and gradual way, but the Secretary of State disapproved, and it was, as I said, vetoed; since then another act has been passed, which was supposed to meet the objections made to that first passed, but an attempt is now being made to induce him to veto it. He has not done so yet, and I do not know whether he will. But the present act is a very small one indeed. It does very little more than authorise the Government to use the metric weights itself for its own purposes, which hardly needs an act one would think, as, there being no law upon the subject at all, anybody, in fact, may use any weights he pleases.

11,893. Not excepting the Government?—Not excepting the Government. Besides those questions as to administrative advantage which the Government might derive from an improved use of scientific advice, there is the further question of the co-ordination of the scientific research, such as it is, which goes on in India under the control or with the support of the Government, with that of England, and no doubt this would be much facilitated by a system of reference to a body able to view the whole in a systematic way. I may notice that astronomical observations are made at the single observatory we now have in India at Madras. The system on which they are made was referred for advice to the Astronomer Royal, and I understand that the Madras Astronomer is now to a certain extent guided by certain instructions that were drawn out by the Astronomer Royal. There can, I suppose, be no doubt that if astronomical observations were carried out in a systematic way at the different observatories in the different colonies and parts of the world over which England has an influence, more useful results might be obtained than if the observations were made without reference to one another. This remark will equally apply to the meteorological observations which are made in India. On this subject I would say that there is no doubt at all in my mind that India is the place of all others where such observations may best be made with a prospect of advancing meteorological science, or, rather, I might say, of creating it; for it can be hardly said to exist at present: I think that there are very few measures at present which would be more important for the general progress of science than some effort in that direction. Within the last few weeks an illustration of the practical importance of meteorological knowledge to India has been exhibited by the tremendous cyclone which caused such destruction at Madras and in its neighbourhood. I see from the last newspapers that an inquiry is going on at Madras with a view of ascertaining whether the Government officers there, the astronomer and the master attendant, are or are not to blame for not having given the shipping notice earlier, that there was a probability of this storm coming on. There is another extremely important inquiry connected with this same subject: in the cyclones which occur in Bengal, there is commonly a tremendous wave formed at the mouth of the Hoogly, which raises the water 16, 17, or 18 feet above the level of high water at spring tides at the mouth of the river; the consequence is that the neighbouring districts are subject to the most terrific inundations, and, in order to prevent them, it would be necessary to raise very high embankments at the mouth of and along the banks of the Hoogly. And then the question arises, if those embankments are made, what would be the result on the river? Would this tremendous wave run up the river in such a way as to be dangerously destructive in the upper reaches? Some people said, if you make the embankments, Calcutta will, on an occasion of that sort, be 12 feet under water, which is not an agreeable result to contemplate. The question was referred to the Astronomer Royal for his opinion whether, supposing we embanked the Hoogly, there was any such danger of Calcutta being put under water. That, again, is one of the practical questions which arise in which it is necessary to call for the assistance of science.

Before leaving the subject of the prosecution of scientific research in India, I would beg leave to say that if England desires to promote the progress of science it ought not to consider that everything that is done for that purpose in India should necessarily be paid for by India itself, because India is so extremely poor that if that principle is affirmed, you will not get it done at all; and if England, under the feeling that it is the duty of a great country like this to promote science, desires to carry on scientific researches out of the country, it should not hesitate about spending a little money in India as well as here.

There is one other manner in which the proposed body might, I think, be useful, which has been suggested by others, namely, that it might attempt to organise, in some degree, the independent scientific societies, which appear, at the present time, to do their work in rather a straggling way. I do not say this with any intention of making disagreeable reflections on any of the scientific societies, but I think that some sort of organisation, or some sort of amicable relations, might be established between them which would tend to their own convenience, and, among other things, to the saving of their money, and enabling the money which comes under their control being more usefully appropriated.

11,894. (*Chairman.*) Can you point out any special instances of what your refer to?—My ideas have been suggested from what I have heard other people say; but I may give as an illustration of my meaning that there is a great deal of money spent upon house rent by the different learned societies, and if they could be got to combine and to use rooms in common, which, to a certain extent, I should suppose might be done, and, to a certain extent, I believe, is intended to be done by some of the chief of them in the new building at Burlington House, economy might be effected in that sort of way.

11,895. (*Mr. Samuelson.*) You consider it essential, do you not, that the scientific council should be nominated by the minister?—Yes.

11,896. If he is qualified to nominate such a council, would he not be equally qualified to nominate persons without the intervention of the council to conduct such investigations as might be desirable?—I think I replied to that, though, perhaps, a little indirectly, in what I previously said when referring to a suggestion that the duties I propose to lay on the commission might be performed by the scientific government department itself, through the Under Secretary. I said that I thought such a functionary would not possess the necessary breadth of knowledge. I also implied that it would be desirable, for the general purposes in view, that you should have a certain continuity in the existence of the advising body; and I do not think that it would be altogether satisfactory for the minister on every fresh occasion that arose, to make a fresh inquiry as to whom he should consult, and appoint fresh persons to help him. There would be con-

Maj.-Gen. R. Strachey, F.R.S.

12 June 1872.

siderable convenience to the minister, and a better prospect of getting useful administrative aid, in having a body that would remain in existence for some time, and so acquire a certain practical ability in dealing with the sort of questions that came before it, and that would be able to make its recommendations in harmony one with another, which I think is also an extremely important thing.

11,897. The difficulty that arises in my mind, and on which I would like to have your opinion, is this, that if the Under Secretary were likely to commit an error in his selection of the advisers upon any specific subject, that error would probably attach only to that special instance, whereas if an error were committed in the constitution of the council, or the commission, in the first instance, that error would be apt to run through all the proceedings of that council, and, therefore, be liable to be much more prejudicial?—Of course, as far as it goes, that objection is real and solid; but I think that it is a sort of objection which is applicable to every permanent appointment of every description. But if there is a risk, on the one hand, of a wrong man being selected for a permanent post, there is a certainty, on the other, that by constant change you lose a great many of the advantages which you would obtain by continuity.

11,898. But the choice is not between a council constituted in the way you propose and no council at all, but between that council and a council constituted in some other way; as for instance, one constituted of heads of departments with certain other *ex-officio* members; and the question is whether the advantages or the disadvantages of each of those two modes would be greater or less?—Perhaps I do not exactly understand what is meant by the expression "a council "of heads of departments," or to what departments the question refers.

11,899. A council of the various scientific departments now connected with the Government, as, for instance, the Astronomer Royal?—No doubt a useful council might be so constituted, though I should not myself prefer that plan, and if it were adopted I should be disposed to exclude the military and the naval departments.

11,900. You think that those departments should be self-contained as far as scientific information goes, or if they were in want of information they should apply for it where they thought it could be best obtained?—Yes, I think so, for the practical working of their own departments and branches of administration.

11,901. (*Professor Huxley.*) Does your objection to *ex-officio* members apply to persons who are at the head of purely scientific establishments, like the Astronomer Royal, the president of the Royal Society, the superintendent of the Natural History Collections at the British Museum, the director of Kew, and other persons of that stamp?—My objection to *ex-officio* members is merely this, that I think the qualities which would be required of the commission, according to my conception of it, are not necessarily those which would be found in the head of any particular department at any particular time. From amongst those heads of departments you might be able, very probably, to select some of the best possible men for the commission; but it does not follow that every Astronomer Royal would necessarily be the sort of man that I should like to have in the commission, neither does it follow that the man who is at the head of the British or any other Museum at any given moment would be so. I do not say that I have any objection at all, or could have any objection, to such persons on account of their holding those posts, but I think that it would be better to make a selection. I conceive that for practical and useful purposes the council ought to be more or less *en rapport* with the minister and with the scientific department; and that if the department or the minister were saddled with *ex-officio* members who did not possess their confidence, or act in harmony with them, it might seriously damage the practical utility of the commission.

11,902. Even supposing that those *ex-officio* members were balanced by a sufficient number of nominated members, what would you say?—Then we come to the difficulty of the number; if you introduce the *ex-officio* element, then, as you say, it may be necessary, according to such a scheme, to introduce an additional number of nominated members to balance them; and the question arises whether you do not then get an impracticably large body.

11,903. (*Mr. Samuelson.*) Taking a very important department which is now in process of development, the Department of Public Health, would you say that it should be self-contained with reference to all scientific questions arising under it?—Certainly. I look upon the administrative departments of the Government (if they are to be carried on at all effectively) as necessarily requiring to be self-contained. I feel satisfied that whatever was proposed, it would be impracticable to work any such department on any other basis; that the department would not and could not submit to it; they would not undertake the responsibility. If, for instance, the executive health department of the Government had to carry on its operations under instructions received from a body of this sort, it would almost necessarily follow that the department would say, we cannot accept any responsibility for what is done under such a system; we do not accept the dogmas of your central council, and we cannot usefully act under them.

11,904. Could you give any instances of the subjects which should peculiarly be referred to the central council, seeing that education, within very wide limits, would also, under your scheme, be a Government Department, and which, so far, should be self-contained?—My understanding would be that, so far as the application of existing knowledge is required by any branch of administration for its regular duties, that branch of administration should be responsible for finding its knowledge and for applying its knowledge; but that occasions would arise when the department would have sufficient humility to say, there is an extremely disputed or difficult point, and we should like to have the very best scientific advice on it, apart altogether from administrative practice. As regards sanitary questions, let us take that of infection, supposing that subject were in a position in which such inquiry could be made regarding it. What is the nature of infection, or under what circumstances does infection arise? That might very properly be referred, as a special question, for consideration purely in a scientific point of view, taking a scientific aspect of it.

11,905. Would not that be rather a roundabout way on the part of the Health Department of obtaining information?—I think not necessarily, because, as I endeavoured to explain before, the Health Department merely deals with questions of medical or biological science, whichever you term it, in reference to the particular subjects that come before them; it is a department to give practical application to scientific knowledge of a certain sort. If a reference of the sort I have spoken of were made by the department to a board like this, supposing that board is satisfactorily constituted, they would be in a position to recommend some course, or, at all events, to take the steps for making any necessary inquiry on any specific point, and they would be supposed also to be in a better position than anybody else to induce the responsible minister to accede to any reasonable request made in that behalf.

11,906. One might say almost that they would act the part of umpires between the department and the minister in any case of dispute?—Either as a sort of superior scientific adviser, or as an umpire. I think that last would be one of their most useful functions; but I feel quite confident that it would entirely destroy the activity and usefulness of any public department, to make it responsible for carrying out any of its duties under the dictation of any such board.

11,907. Even in such a case as the appointment of the recent committee on the construction of ships, do you think it requisite for such appointment that it should rather have emanated from the responsible

Maj.-Gen. R. Strachey, F.R.S.

12 June 1872.

officers than from the minister ?—I would not draw any precise line. There would always be a tendency in any department for the officers to think that they are better than they really are ; and the minister may have a justifiable cause for thinking that the officers are not quite so good as they affect to be, or as they think themselves to be, and he may be perfectly justified, therefore, in desiring that some investigation should take place outside of them.

11,908. In such a case as that would you have considered it more desirable that that investigation should have been conducted by persons appointed by the supposed scientific commission than by a committee appointed by the minister direct ?—I think, practically, the results would be pretty much the same; under the existing system the minister appoints a committee or commission, after having gone about and made inquiries, and having tried to satisfy himself who is the best possible person to consult, while, on the other plan, he would remit the question to the commission, which would make inquiries, but the presumption is that they would be in a better position to make such inquiries, and to arrive at proper conclusions, after having made them, and could better advise the minister whom he should consult.

11,909. That would be one of the functions which you would like to see exercised by the commission of which you are speaking ?—Yes, in relation to those subjects.

11,910. You mean so far as purely scientific questions or mixed scientific questions are concerned ?—Yes. In a case such as you refer to, the minister would have to decide whether the question at issue was really a scientific question, or whether it was an administrative question. It is not a very easy thing always to draw the line exactly between the two, and he would either ask the advice of such a commission or he would not, according as the scientific part of the inquiry predominated, or what you may call the practical or the administrative.

11,911. Referring again to India, do you think that the question of the establishment and organisation of the Civil Engineers' College might fairly have been left to a body of that kind, if it existed ?—I do not think there could have been any objection to it.

11,912. But is that one of those questions which you would have liked to see referred to such a body ?—If there had been any general wish or any largely expressed wish on the part of people in England that there should be such a reference, I can only say that I could not see how there could be any objection to making it. I am not altogether prepared to say that, necessarily, very useful results would have come from it.

11,913. I am endeavouring to arrive at what amount of science you think should turn the scale ?—It would be extremely difficult to say. I think in all those cases that whatever rules you make, the responsible minister, in every department, will in each particular case act as he likes. He is a great deal too powerful to be bound by any rules that are made for defining the duties of a scientific commission.

11,914. Do you think that the question of the proper gauge for the Indian railways would have been referred to a body of that sort ?—I am very much mixed up personally with it, but I should have said certainly not. I look upon that as entirely a departmental question ; I do not think it is in any sense scientific. One can hardly say that any scientific considerations, properly so called, very much affected the decision which was come to.

11,915. In point of fact, it would be questions rather of pure and experimental science than mixed questions, involving much in the nature of administration, for which such a council would be used ?—I do not know that I could put it more definitely than I did before.

11,916. With reference to India as well as to England, you would lay down the same rule that the functions of the council should be confined to new matters rather than those which had already been taken up by the departments ?—I think so ; each administrative department of the Government should be responsible within itself for the application of existing scientific knowledge to the objects which it has to carry out, but if anything occurs beyond that, or which requires any exceptional application of knowledge, then a reference might properly be made to such a council for assistance or advice.

11,917. (*Chairman.*) Are there any other points upon which you would like to make additions to your evidence ?—I am not aware of any.

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 14th June 1872.

PRESENT :

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
BERNARD SAMUELSON, ESQ., M.P.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.

THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

J. Anderson, Esq., LL.D., C.E.

14 June 1872.

JOHN ANDERSON, Esq., LL.D., C.E., examined.

11,918. (*Chairman.*) I believe you have been for many years in the War Department ? — About 30 years.

11,919. What appointment have you held in this department ?—I entered as engineer at the Royal Brass Foundry, and some eight years later I was made inspector of machinery over all, and after that I had the entire charge of the gun factory, and when I left that, about nine years ago, I was made superintendent of machinery, my duties extending everywhere.

11,920. And that is the office which you hold at present ?—Yes.

11,921. You have had great experience in carrying out mechanical engineering work generally ?—Very great.

11,922. And you have organised a number of important manufactories for small arms and other war stores ?—Yes, such as that at Enfield, and for the production of fuses, shot, shell, and war stores generally.

11,923. You have been responsible for the expenditure of a very large sum of public money ?—Yes, very nearly 3,000,000*l.*

11,924. You have no doubt had to consider the relations of the Government to science ?—I have.

11,925. Have you formed any opinion as to whether a consultative council would be a great advantage ?—It might be to a certain extent. I have read the précis of Colonel Strange's evidence, and when that proposal was first suggested to me, I was rather inclined to concur in those views, but on further

J. Anderson, Esq., LL.D., C.E.

14 June 1872.

reflection, I fancy that it would not be satisfactory in the long run; that it is too large a scheme, and that the work really would not be so much advanced by such a Council as it might appear; that it would fall more upon some individual who would really have the whole work to do, and whose knowledge on the point that he advanced would be the knowledge of all those who had to speak about it. It seems to me that a much smaller committee, with power to select the best men in the kingdom to carry out experiments, would be more satisfactory.

11,926. Can you give the Commission a statement as to the mode in which the Government (so far as you have had experience of its proceedings) acts, when it requires scientific advice, at present?—As a rule scientific questions of the kind referred to in the précis that I mentioned, are settled by the Ordnance Select Committee, of which I was a member for a few years. When the questions came forward some one individual, very often myself in those days, had to investigate the matter so far, and then to write something about it; the subject was then discussed at the general meeting of the committee; but since that time a great change has taken place. A good many scientific men have been rising up from year to year, and at the present time the most of the knowledge that the War Department requires it finds within itself.

11,927. Do you think that it is generally able to obtain scientific advice of the highest quality?—I do not remember any instance of their going outside for it. It generally comes voluntarily from the outside, when anything fresh comes in, such as in the case of Sir William Armstrong and a great many others, who are continually pressing things upon the Government. Some are worthless and some are valuable; but there is a great deal of scientific knowledge contained within the War Department, although it is very quietly conducted. The names of the individuals I daresay are very seldom heard. There are some men whose names have never been mentioned, very obscure men, in the War Department, who nevertheless go to the bottom of the questions connected with some of those things which are referred to in a part of my letter as quoted by Colonel Strange; but still there is nobody in the Arsenal that goes thoroughly into the class of subjects that I refer to, that is something a long way beyond anything that we now attempt, but still they are further advanced in the Arsenal than in any other place that I know of in reference to ordinary knowledge of cast iron and many other collateral subjects.

11,928. Do you think it would be desirable that they should have some other regularly constituted scientific council or authority to whom they could appeal?—It might be, I could easily imagine that it might be so. I do not sit here to say a single word for the War Department from any selfish or interested motive, but at the same time I am quite sure that there is far more within the War Department of real science than the world is inclined to give credit for.

11,929. Have you had any occasion to form a decided opinion as to the need of anything further than exists at present?—There is a very great deal which I should like to see taken in hand systematically.

11,930. Will you point out what changes you would like to see introduced?—There is that question in my letter which Colonel Strange refers to; I think that is a most important one, and although we know a very great deal with regard to iron, cast, wrought, and in the condition of steel, there is yet very much which we do not know, and I am persuaded that if we could, with certainty, treat ordinary cast iron in the way that we sometimes do, nearly by chance, we should do away with three-fourths, or a very large proportion of the wrought iron which is now used in this country, and we should use cast iron. A great deal of the cast iron of commerce is not much above five tons per square inch in tenacity, but we can, by trying, get it up to 15 tons, although some of the reasons that determine that high character are obscure and it is very difficult to see what they are. I should like that the subject of cast iron should be thoroughly exhausted, and at the same time I should like to see the physical properties of iron thoroughly exhausted. In 1847 a Royal Commission was appointed to investigate iron with reference to the fall of a certain railway bridge. Lord Wrottesley was the chairman of that Commission, which did an immense deal. I consider that the Blue Book which contained the result of its proceedings has done more to enlighten us with regard to the minutiæ of knowledge relating to iron than anything that had been done before, or has been done since. And what I should prefer would be one or two men, not such a cumbrous machinery as a Royal Commission, set to work with a proper laboratory and with every apparatus to carry out what we want to know, and to work it through by private experiments, not twice or three times, but hundreds of times, so that we should soon come to know the natural laws that govern elasticity, &c. From all the experiments that are referred to in books that I have seen, and I have made some thousands of experiments testing the elasticity of materials, according to all that has been shown by the short specimens, one is inclined to say that Hooke's law is right, and that there is a point where elasticity may be considered perfect, a good way towards the ultimate breaking strength of the material, but, according to those experiments made by the Commissioners, it is shown that the elasticity is scarcely perfect even at the commencement, and that elasticity continues even to the end. With regard to that Commission, if only more of its time had been spent in repeating a number of the experiments, and if it had been associated with chemists who could have worked out the other questions that we referred to a minute ago, and if some one could have been told off to reduce all that that Blue Book contains, so that we could grapple with it; there are hundreds of lessons taught in that book if people would take the trouble to wade through it, but it is a great labour to get at it, and so it passes away without being read scarcely by anybody. In my opinion there is a mine of knowledge in that book, and a mine of wealth to this country if it were studied and reduced to practice. What I should like to see would be some two or three scientific men who would work out the chemical and physical facts that we wish to reach; and that they should work in harmony, with the aid of plant and apparatus and all things necessary to get at the knowledge that we wish for, and that they should be supported and properly encouraged until the thing is done; but I do not think that a great council could do much towards helping forward the ultimate result that we would arrive at.

11,931. Have any proposals of the kind ever been submitted by you to the heads of departments?—Never. I have watched this sort of thing for years, and have thought it over, but I have never spoken about it. There is another very important subject which I might mention to the Commission. Some twenty years ago, we were using ten or twelve pounds of coal per horse-power per hour, and the majority of engines still require six pounds, but by the improvements that have taken place we are now down to two pounds. There is a little engine at work now in the London district which is working at one and three-quarter pounds. There is a great gulf yet between getting steam engines that will work at one and three-quarter pounds per horse-power per hour, and the point where we are now, I mean getting that done practically, but I believe that if the right man, or two men, were told off to thoroughly investigate this subject, and not to stop working until they had brought it to a practical shape, we could in ten years, from this time, get down to one pound per horse-power per hour. I see that there are very many leakages of loss in steam engines in the very best way that we make them at present. The knowledge that was gained by Joule's experiments a few years ago seems to me to have been of immense value. Those experiments that he carried out for himself were the sort of thing which I think the Government should have done for the sake of the

J. Anderson, Esq., LL.D., C.E.

14 June 1872.

country. He did more to make engineers thoroughly dissatisfied with their present knowledge with regard to what they can do with steam than anything which had been done before. I believe that what Mr. Joule did will do more for this country than even what James Watt did. The part that James Watt took was very great, and the world gives him full credit for it, but the world is scarcely willing to give credit to Joule for what he will do; but he has made all engineers dissatisfied. They know that the best steam engine is not doing one-sixth of the work which it ought to do and can do. That is a sad state of matters to be in when we know that we are so far wrong, but yet no one will go to the trouble of going to the end of the question so as to improve the steam engine as it might be done; in fact, it will cost a great deal of trouble and a great deal of expense, I have no doubt.

11,932. (*Sir J. P. Kay-Shuttleworth.*)—The public are not sufficiently interested in the particular question at present to exhaust the subject, and you think that such an investigation ought to be undertaken in the public interest by the Government?—That is my decided opinion.

11,933. (*Chairman.*) Do you think it desirable that the Government should establish any laboratories for carrying on these investigations?—I should like to see a grand laboratory fitted with everything that would go towards the investigation of such matters, and at the same time a testing apparatus for getting at the physical facts as well. To get up the proper plant would be very expensive, but still I should like the nation to have it, so that any public department could go to this same laboratory and ask them for assistance to investigate any doubtful point. There are many doubtful points now that we cannot get to the bottom of. We see in the newspapers from time to time that shells are breaking, and other contingencies of that description. For although there is a great deal known of the natural laws that are at work that determine these things, there are yet a number of nature's secrets that we do not know anything at all about. When a shell is broken, we see that the crystallization is very fanciful in the lines of direction of the crystals, and not always the same way, showing that there are natural laws at work that determine them. It might be inferred sometimes that the crystallization was nearest the line into space at which the heat passes off, but we sometimes find it away from that and going in curved lines, and in following that up we find that it is when it comes in contact with anything cold, which hastens the withdrawal of the heat in that direction. In the Government service everybody who gets any work to do worth mentioning is overpowered with work—either they get too much or too little to do—and the investigator should not be bothered with such miscellaneous work. For example, take my own case, I may have 50 subjects in a day many times. Yesterday I had well on to 50 subjects to take up, and go into them all as well as I could, and I did not get over my work to write the paper which now lies before your Grace until 9 o'clock last night. A man cannot do justice to pure investigations when he is overloaded in that way.

11,934. The laboratories that you recommend would be mainly for purposes connected with the public service, would they not?—I would like to see such a laboratory taking up every scientific question that would bear directly, or even indirectly, on any of the industrial processes; and then any Government department could consult and get information from an exhaustive laboratory of that kind.

11,935. (*Dr. Sharpey.*) I presume you mean that certain questions would be referred to selected men of science, to be worked out by them working in that laboratory?—Yes, that is what I should recommend.

11,936. It would not be a laboratory really open to all comers?—No, I should not like it to be that. The arrangement which I think would work well would be to have a very small council, not paid high salaries, and without expecting the whole of their time to be devoted to the subject, but to give them a retaining fee of say 500*l.*, or something of that kind, for a dozen or 20 meetings in the year, and that they should have the power to decide on the questions that require investigation, or to consult others with regard to subjects that required investigation, and that they should select the best men that could be found, men like Michael Faraday, and men who will really work, because such knowledge can only be obtained by those who can work and will work, and who have the head as well.

11,937. (*Chairman.*) Are you able to give any opinion as to how many members this council ought to consist of?—I have not thought of that.

11,938. But you think that it should be a small council?—Yes, I should think a small number would be better than a large number.

11,939. Would you say six or seven would be sufficient?—Seven would be sufficient, and likely to work well.

11,940. Have you thought how they should be appointed; whether any of them should be *ex-officio* members?—I have not thought of that. Much would depend upon the men, no doubt, and the difficulty would be in preventing interest and self-seeking.

11,941. Without the assistance of some such council as this, you do not see much prospect of the Government causing such inquiries to be made as you think desirable?—I see no symptom of it at the present time.

11,942. At present, if they felt generally the necessity of instituting such investigations, they would probably feel some difficulty in discovering how to proceed in the best way?—They would, indeed. I rather like the idea of the council having authority, because I feel sure that the weight of their opinion, when it came to bear upon any branch of the Government, would tell more than the opinion of the smaller men within the department, and that the Government would be less likely to overrule such good advice from the council than it does from individuals.

11,943. What is your opinion as to the necessity of any experiments for ascertaining the relation of the different metals and alloys?—There is much to be done in that direction.

11,944. (*Sir J. P. Kay-Shuttleworth.*) I think you complain that the amount of administrative work which necessarily falls upon you personally prevents you, in the relation which you hold in the great department with which you are connected, to a very great extent, from pursuing original research?—Yes.

11,945. Supposing that a limited council, such as that which has been suggested, existed, it would be very important, would it not, that the council should have the full benefit of all the opportunities of observation which you have had of the wants of your own department, and that you should have some tolerably direct relation with that council, so as to enable you to suggest subjects for investigation affecting practically the wants of your department?—Yes, it appears to me that something of that kind would be quite necessary.

11,946. (*Dr. Sharpey.*) Would you connect that council with any particular Government department?—I should like it to be under the department for education. It seems to me that education is just a part of it. We find ourselves in a little world governed by certain principles, and men in the course of time come to invent languages, but these all come after the kind of thing that we have been speaking about to-day, although men put them before it. Men say that reading, writing, and arithmetic are the things that we have to teach, but there is something before that really existing around us, whether we learn to see it or not; and it seems to me that the minister in administering the education which comes a long way after what we have been speaking of, should take the first upon which everything depends, and that the science and the education should be under one head.

11,947. Does it occur to you where such a labora-

J. Anderson, Esq., LL.D., C.E.

14 June 1872.

tory might be placed ?—Somewhere near London, but I have not thought of the place; a part of Greenwich Hospital might be suitable.

11,948. You would not have it in connexion with Woolwich, would you ?—There is too much at Woolwich already, in my opinion.

11,949. (*Chairman.*) Colonel Strange, I think, recommended two or three laboratories; a chemical laboratory, a physical laboratory, and a physiological laboratory; do you concur in that opinion ?—I should prefer them all to be together in the same range of buildings, because they would be large buildings; and I should like to see them under one head, and I should like not only to see the best man that could be got in each branch, but I would prefer an administrative man rather than a scientific man over the three, and I have reasons for wishing that; I think that it would work better and produce greater harmony if the three were on a par, with an administrative man over all of them, and higher than either, even although he had not so much scientific knowledge; I should like him to have great wisdom rather than mere knowledge, and there is a mighty difference between the two, because a man may have plenty of knowledge and may have no wisdom, or a man may have plenty of wisdom but may have comparatively little knowledge. If you go into the country you sometimes find a farmer with wisdom that you would almost think could govern the nation; and you may find a man of great scientific attainments with but very little common sense.

11,950. Are you quite satisfied that the investigations which you contemplate would sufficiently occupy the laboratory, and that there would be no risk of its remaining unemployed ?—Not for a long time to come. There is much that we are in the dark about; we are groping in the dark in almost everything at present.

11,951. New and important questions would arise requiring investigation ?—Yes.

11,952. And you think that those should be investigated in this State laboratory, and also that all the expenditure connected with those investigations should be defrayed by the State ?—I am decidedly of that opinion.

11,953. (*Dr. Sharpey.*) You look upon such a laboratory as important, not so much for the sake of giving opportunities to independent workers in science as for the solving of those important questions which you refer to ? Yes, that is what I would like to see, for the solving of those questions. It would affect the country immensely if we could get through them. It will come in time, I have no doubt, by private enterprise. We are going at a great pace now, but there are a few things which, if they were solved, would liberate the energy of the country to an immense extent.

11,954. Mr. Joule made all his important experiments at home, did he not ?—Yes.

11,955. If there had been such a laboratory as we have been speaking of, would it have been of any advantage to Mr. Joule in his investigations ?—It might have been advantageous to Mr. Joule to have the use of that laboratory, but no one could have done it better than he did. Two or three have gone through the same thing in Germany or in France; I forget at this moment which, but they all agree that what Mr. Joule did is the best, and the advantage derived from the way in which Mr. Joule put it to the world is, that he put it so plainly that everybody can understand it. The little amount of heat necessary to raise a pound of water one degree will lift 772 pounds one foot; that anybody can understand and carry away. There are very many books written by those who investigate such subjects, which really one cannot understand.

11,956. That great and important result was attained in his private laboratory, and, no doubt, he happens to be a gentleman who can afford to give the time and bestow the expense required; but it is not so much for such cases that you think the State laboratory would be useful as for the resolving of special questions referred for investigation ?— That question is solved as far as Mr. Joule is concerned, but there are other points which cause more difficulty as you get closer to the practical application. It is very well to say, "Do this and that" to the steam engine, but the question is how to do it. Men will what is called invent this, that, and the other, for hundreds of years, and I daresay they will come to it at last, but I really believe from my own investigations last year, in the way of closing up the leakage of heat that passes away from steam-engines, that we are not far removed, if any man will take the trouble to spend the money, from getting steam-engines that will work as well as our present engines work with a pound of coal per horse-power per hour.

11.957. (*Chairman.*) Have you the power of carrying on investigations, at present, at Woolwich, to a certain extent ?—I have not the time, and there is no one there who systematically works in that direction.

11,958. How far should you be able yourself to carry on investigations if you were relieved from some part of your ordinary routine duties ?—I should not suppose that I was the one to carry on experiments of this kind; I would not suppose that I had the knowledge. It wants men of great learning, but it would be all the better if they were practical men, because if there were a practical man with Professor Tyndall, or some one who knows all about heat, and everything connected with the collateral subjects, associated with the practical men, I believe that we should very soon reach the pound of coal standard.

11,959. You have drawn our attention to the difference between wisdom and scientific knowledge; which do you think is most required in the members of this scientific council which you would recommend ?—I fancy that the president should have the wisdom.

11,960. But you think that a large amount of scientific knowledge would be essential for the members of the council ?—Yes, certainly. Faraday would have made a capital member, but I am not sure that he would have made so good a president as he would have made a working member.

11,961. Do you think it would be possible that the minister himself should be the president of the council ?—If he had the time to give to it that would do more to keep every one up to the work than anything else, I am quite sure.

11,962. (*Sir J. P. Kay-Shuttleworth.*) Might there not be probably a scientific permanent secretary of considerable position, with a general knowledge of science and with large administrative experience, who might preside over the council ?—Yes, that would do very well.

11,963. (*Sir J. Lubbock.*) In the examinations of the science schools, would you make the marks dependent in any way upon the literary ability of the student ?—When two papers are of equal scientific value, I read them again and give the preponderance to the best written paper.

11,964. That is, I presume, in the case of competitions ?—Yes.

11,965. But as far as pass-examinations are concerned, if the scientific answers were correct, what would you do ? I then neglect the best literary papers unless they come to be matched with one another.

11,966. As far as passes are concerned, you would make them depend upon the scientific knowledge which the paper exhibited ?—Yes. I am rather pleased to see those who have not much book-learning taking to scientific work.

11,967. You would be sorry that any person who had scientific knowledge should be excluded on account of his absence of book learning ?—I saw some papers marked "ploughmen," and I looked them up. They were very low of course, but one could not help being pleased to see ploughmen working at a thing of that sort, probably having to walk every day about four or five miles to the classes. The spelling is very bad sometimes, but I am quite sure it is improving.

J. Anderson, Esq., LL.D., C.E.

14 June 1872.

11,968. (*Dr. Sharpey.*) Did those ploughmen answer upon mechanics?—Yes. In the country they will very soon require ploughmen to know mechanics; and I was rather pleased to see that those ploughmen were in various parts of the country. I do not know how they came to have a class that they could go to, because they are so isolated; but there are a considerable number of ploughmen in various parts of the country who send papers for examination, especially in Forfarshire.

11,969. (*Chairman.*) Do you refer to ploughmen employed in steam cultivation?—All that I have to guide me is just the word "ploughmen" as the avocation, placed opposite to the name of the student. [*See* APPENDIX XII.]

The witness withdrew.

W. Spottiswoode, Esq., F.R.S.

William Spottiswoode, Esq., F.R.S., examined.

11,970. (*Chairman.*) I believe you are vice-president and also treasurer of the Royal Society?—I am.

11,971. And also connected with many other learned societies and institutions? With the British Association, and with the Royal Institution, the Mathematical Society, and others.

11,972. Have you seen the proposals of some of our former witnesses for a council of science to advise the Government? I have.

11,973. Are you favourable to the appointment of such a council?—I think it is the most complete and perfect suggestion that has yet been made, and I have always looked upon it as an arrangement to the carrying out of which all others should be directed; but at the same time the proposal is a large one, and it might be worth consideration whether some intermediate scheme for earlier action should be proposed.

11,974. If any council (without at present going into its constitution) were appointed, in whose hands do you think that appointment should be placed?—I think it clearly should be in the hands of the minister with whom it would be in direct relation.

11,975. You would leave the choice absolutely to him and not make the appointments in any respect *ex officio*?—There might very well be certain *ex-officio* members, such, for instance, as the Astronomer Royal for the time being, the president of the Royal Society for the time being, and perhaps others.

11,976. Do you think that the members should be paid?—I think that if the business of that council were considerable, if the occasions on which they should be consulted by the Government were frequent, and if they were expected to undertake any long investigation, it would be quite necessary that the services of the council, and of those who, under them, undertook those investigations, should be paid.

11,977. What is your opinion as to whether the appointments should be for life, or otherwise?—I think that they should be made for a period long enough to see any of those long questions carried through; that they should be long enough to enable the members to get thoroughly into the working of such a system, but I should be indisposed to suggest that they should be made for life. The case which I have in my mind is not quite parallel, it is true, but in connexion with the India Office there is a Council whose appointments are now made, I believe, for a period of ten or twelve years; they are paid and meet regularly, and a great number of questions, probably all large questions connected with the Government of India, are referred to them, and I believe that their advice is found of the greatest possible service to the Secretary of State for India. They are paid members, and their appointments, originally made for an indefinite period, have been of late years restricted to a definite period, I believe, of ten or twelve years.

11,978. And you think that a similar arrangement would probably be desirable in the case of this proposed council?—I should think so.

11,979. Have any modifications suggested themselves to you as respects the council that has been proposed by former witnesses?—At present it is the custom, on many occasions, for the Government to ask the advice of the Royal Society upon questions submitted to them, or arising in the progress of their administration, and the Royal Society has, whenever called upon, given its best attention to those questions in response to the inquiry. I do not think that it would be possible for the council of the Royal Society to undertake very much larger labours than they at present do; but, at the same time, I think that they might be asked whether they could on more frequent occasions, or perhaps upon even larger questions than they have hitherto been consulted upon, appoint special committees *ad hoc* out of their members, or other persons versed in the subjects which were referred to them. In that way they might largely assist the Government on scientific questions.

11,980. Do you think that, with certain modifications, the present system would be adequate for the object in view?—Certainly not adequate for the objects which former witnesses, or I myself, have ultimately in view; but the work of such a council, the nature of it, its functions, its power, and its duties would very much turn upon the circumstances from time to time. It would depend very much, for instance, upon the degree and the extent to which the Government chose to avail itself of its services; and I would suggest, as a material consideration, that the importance of such a council, its work and its activity, would depend, not primarily upon itself, but upon the Government who consulted it. If the Government should abstain from consulting, the functions of such a council would tend to die out. If, on the other hand, the Government were disposed to avail themselves largely of their advice, the council would become a very important body in the country; and, therefore, with every good disposition on their part, the importance and value of such a body would depend very much upon the mode in which the Government thought fit to make use of them.

11,981. Do you remember many instances in which you considered that the advice of a council of the kind would have been of great advantage to the Government, and to the nation?—Several important cases have been mentioned by former witnesses. The notable case of the "Captain" has been in the mind of every one; and there have been questions relating to magnetism, whether as a question of physical science or of its importance to navigation in connexion with iron ships.

11,982. In the case of the "Captain," if the Government had thought fit to apply to the Royal Society, do you think that they would have got advice that would have been of great service?—I think that the Royal Society could certainly have nominated a committee, or they could have named individuals who would, when formed into a committee, have been capable of giving very sound advice upon the subject.

11,983. The council proposed by Colonel Strange is very numerous, do you think that a council of that number would be desirable?—I should hesitate to give a decided opinion upon that subject, because, as I said before, not only the functions, but the very constitution of such a council would depend very much upon the way in which it grew up. If it were to comprise all the objects that come under the cognizance of the Government, including those which arise in connexion with both the War Office and the Admiralty, its functions would be extremely wide, and it would be necessary to have a council large enough to comprise one or more members who would be themselves competent to deal with any question submitted to them. At the same time, I should myself conceive that such a council would not unfrequently avail itself of the advice and the co-operation of other scientific individuals, not members of their body.

11,984. It has been suggested by some of the witnesses that a much smaller body might be sufficient for the purpose, not so much to conduct investigations or to give opinions themselves, but rather to point out to the Government where the best advice can be obtained; do you think that a council of that kind would, in the first instance, be preferable to a larger council?—I think it would be better to begin with something on a smaller scale; and it was with a view to that that I alluded to the possible co-operation of the Royal Society through special committees appointed to deal with any questions referred to them.

11,985. Should you, on the whole, be disposed to recommend that the Government should avail itself of the advice of the council of the Royal Society in the manner proposed rather than appoint a special council, consisting of large numbers?—I think that if the Government contemplated availing itself more frequently and more systematically than heretofore of the advice of scientific persons, it might be well, as an immediate step, to ascertain whether it could not avail itself more largely of the advice of the council of the Royal Society than heretofore, and as soon as the work became too much for them to deal with, either themselves or through committees of their fellows, then I think would naturally arise the question of appointing an independent council. In my opinion if the Government for the time being should adopt such a course, such question would very shortly arise, and probably the nature of that council, its magnitude, and its constitution would, in a great measure, be suggested by the circumstances which rendered its existence necessary.

11,986. Do you think that the functions of such a body as that which has been proposed should be purely consultative?—I think that the initiative should always be taken by the Government; that it should not be the function of such a council to offer spontaneously advice to the Government, but to give their advice, their opinion, their co-operation, and such information as they were able to obtain, upon any question upon which the Government consulted them.

11,987. Has the Royal Society ever made proposals itself to the Government without being asked their opinion on matters of science?—They have from time to time.

11,988. The British Association more frequently perhaps?—As frequently. And I do not consider that the existence of the proposed council need in any way interfere with, perhaps it might rather assist, proposals from either of these bodies.

11,989. Colonel Strange and some other witnesses have recommended the establishment of laboratories at the public expense; have you considered that question?—I have to some extent.

11,990. Do you concur in their opinion that the Government ought to establish such laboratories?—I think that there are many questions on which it is absolutely necessary that the researches and observations should be carried on at the Government expense. We have already in existence several such establishments: first, the Royal Observatory at Greenwich, carrying on the ordinary astronomical observations, and, to a certain extent, also magnetical and meteorological observations. We have the Meteorological Department of the Board of Trade, with its own central observatory at Kew, and other observatories in various parts of the country connected with it in respect of meteorology, where observations and experiments are continuously carried on. There is the Ordnance Survey at Southampton, and no doubt other establishments of the same kind. These establishments undertake series of observations and experiments which extend over long periods, which require continual, and, in some sense, routine work, and which observations and experiments would be entirely beyond the resources or the scope of any private observatory or laboratory; and few persons have questioned the propriety of maintaining them at the public expense. No doubt, with the extension of science, the scope of those observatories would extend. It has recently been recommended that the Royal Observatory at Greenwich should undertake observations generally known by the name of solar physics, in connexion with its astronomical observations, and that I believe to be only one out of several similar extensions which would immediately or very shortly recommend themselves to scientific people. The scope, for instance, of the Meteorological Department of the Board of Trade, although already wide, is, probably, by no means so wide, in its scope of the phenomena which it takes in, as it may very shortly be expected to be; and, doubtless, the same observation would apply to other scientific establishments with which I am not myself so well acquainted. There are other investigations which it is very desirable, both for the sake of science itself, and for the sake of its immediate utility to the country, should be undertaken. Hitherto, a great many of those smaller researches, it is true, have been in a great measure supplied by the grant made every year by Parliament for scientific investigation, and entrusted to the Committee of the Royal Society for that purpose. Others have been met by certain funds belonging to the Royal Society itself; others, again, by the funds of the British Association, all of which are administered in general principle in the same way. It has appeared that the demands upon those funds have not much exceeded the funds at the disposal of those several bodies; but, at the same time, I think that the adequacy of those funds is, perhaps, on the whole rather more apparent than real, because it has been known beforehand that it would be useless to apply to any of those bodies for a very large grant for research, and, therefore, those large demands have been withheld from the list of applications. Certainly, in respect to the British Association, and, to some extent, to the other bodies, it is generally known beforehand in a general way the funds which might be expected to be available, and the applications of scientific men have been, I know, in some degree, measured by what they knew might be available for such purposes. Therefore, I think that the fact of the applications not having generally exceeded the funds at disposal, is by no means a measure of the amount of the applications that might very properly be made to them if it were known that larger sums would, in case of real necessity, be available. It is through some such agency as that, and an extension of that agency, that I think even somewhat larger researches than have hitherto been contemplated by those bodies might be undertaken. And, although there is no doubt that science would be greatly extended by the existence of large and efficient laboratories in available positions, yet I still think that a good deal might be done by larger grants, utilised at existing establishments, either public or private.

11,991. The observatories which you recommend could, in your opinion, be attached to existing observatories; an observatory for solar physics, for instance?—This might be met by an extension of the existing observatories.

11,992. Do you think that it would be as useful, if attached to Greenwich, as if a special observatory were established for the purpose?—I have no doubt that if an independent observatory were adapted to that purpose and furnished with adequate instruments, and manned by such a staff as one could wish, more would be done in such an independent observatory, so manned, than by a branch of the Royal Observatory at Greenwich, but, at the same time, that would involve such a much larger expense, that I thought that the the question of expense would perhaps outweigh the scientific advantages to be gained by it.

11,993. Do you think that a great deal might be done by making some additions to the present observatories?—A great deal, because in a large observatory there are, not unfrequently, instruments only partially employed. For example, at Greenwich there is a large and very fine instrument suited to the investigation of solar physics, which is, at all events, largely disposable for such observations.

W. Spottiswoode, Esq., F.R.S.

14 June 1872.

11,994. The larger laboratories that have been recommended by some witnesses have been recommended, I think, partly for two objects, partly with a view to the general advancement of science, and partly with a view to conducting investigations directly connected with the service of the country. Have you formed any opinion as to whether they are required for the latter object?—The existing establishments at Woolwich and Shoeburyness for gunnery, at Southampton for the survey, and at the dockyards for shipbuilding and compasses, are doubtless, in some sense, sufficient for the public service. But, at the same time, past experience seems to show that, on many questions arising even in these departments, an opinion and advice in some sort of an independent character (independent, I mean, of the department) would be extremely valuable.

11,995. You have spoken of the Government grant to the Royal Society, and of other funds of the same kind; should you like to see those funds increased by a definite amount, or would you rather contemplate as a preferable arrangement that the Royal Society and the British Association should make, on special occasions, application for larger funds for more expensive investigations?—I think that an extension of the Government grant would be in itself desirable, but that its extension in the first instance should arise out of demands known to exist after no very long period. I should expect that the minimum which might be voted every year would increase materially, and although it would be desirable that there always should be a possible margin beyond the sum voted, yet I think that the minimum voted every year would very soon increase considerably beyond its present limits. These questions run very much into one another, and if it were left to the Royal Society or to any other such private body to make applications, the Government would probably find itself frequently in the difficulty in which it is understood to be now—that is to say, that it would have great difficulty in discriminating between objects which were worthy of a grant of public money, and those which were not. I might instance, by way of explaining what I have in my mind, a case which recently occurred. Application was made by the British Association through its president, Sir William Thomson, for a grant of 150*l.* for the reduction of tidal observations. That application was declined, not on the ground that the object was otherwise than good, nor that it was an object unfit for the expenditure of public money, but because, if the Treasury granted this, they did not see how they would be able to refuse other applications from scientific bodies or individuals. That is to say, that their difficulty lay in their having no means of discrimination and no reliable advice whereby they should tell what application should be acceded to, and what should not be granted. Therefore, unless those various applications of which we were speaking came through some recognised body, it would be the business of the Government for the time being, or the Department to which they were addressed, to judge whether they were applications which were to be acceded to or not, and that is the very knot which I believe it is the desire of this Commission to untie, so that, unless there were some recognised channel through which the application should pass before arriving at the Government, we should not stand in any better position than we do now. I have already made my answer, perhaps, rather too long, but one point in the organisation of the British Association appears to me in some degree to illustrate the point, and it is this,—that every application for the appointment of a committee, whether involving grant of money or not, has to pass through a certain committee called the Committee of Recommendations. That committee is composed of the presidents of the sections for the time being, the president for the association, and other selected scientific members present at the meeting. It is, in fact, the most scientific element in the association, and unless any application for a grant receives the sanction of that committee, it is not by the body itself. Therefore, that body, the Committee of Recommendations, stands, as it were, between the general committee of the association and the particular applicants, and all suggestions, both those of Colonel Strange and of others, have gone to this, that there should be some scientific body to stand between the applications for public money for scientific purposes and the Government who has to make the grants.

11,996. (*Mr. Samuelson.*) You are acquainted, of course, with the contents of the letter of the 3rd of June, in which the Chancellor of the Exchequer declined to entertain the application of the British Association for funds for the reduction of tidal observations, and which is in the following terms:—
" The Chancellor of the Exchequer has referred to
" the Lords Commissioners of Her Majesty's Trea-
" sury the memorial of the British Association for the
" advancement of science forwarded to him with your
" letter of the 21st ult., praying for Government
" assistance in connexion with tidal observations. I
" am to state that their Lordships have given their
" anxious attention to the memorial, and that they
" are fully sensible of the interesting nature of such
" investigations, but that they feel that if they
" acceded to this request, it would be impossible to
" refuse to contribute towards the numerous other
" objects which men of eminence may desire to treat
" scientifically. Their Lordships must, therefore,
" though with regret, decline to make a promise of
" assistance towards the present object out of public
" funds"?—I am acquainted with that letter.

11,997. Does it not appear on the face of that letter that the Government are unwilling to contribute funds for an object which they acknowledge to be of importance, on the ground that it might lead to their having to contribute funds for other objects which they would acknowledge to be equally important?—It appears so. But if a variety of applications were made, which to the Government appeared equally important, and if for any reason they were unprepared to accede to all, they would be in a difficulty, from lack of the scientific knowledge, to enable them to weigh the relative importance of the subjects laid before them.

11,998. Do you think that that was really the meaning of that letter, or are you acquainted with circumstances which would induce you rather to put the interpretation upon it contained in your evidence in chief?—They have already made grants in answer to similar applications. Recently, they granted the sum of 2,000*l.* for the observations of the last solar eclipse in answer to the application on the part of the British Association, the same body as made this application. And, therefore, it appeared to me that, while acknowledging the importance of Sir W. Thomson's application, they found it necessary to draw the line somewhere, not upon any principle of scientific value or of public importance, but arbitrarily, as stated in the terms of their letter.

11,999. So that it is not your opinion that the words in that letter really bear the wide application which at first sight they would be capable of?—I have stated my view of the meaning of the letter, and the ground of it.

12,000. You stated that you would not recommend that the council should suggest inquiries, but rather that they should advise the Government on any questions which might be submitted to them; what is your reason for making that distinction?—I meant, rather, that they should not initiate any questions arising out of the administration of the Government. I did not, however, intend to convey the meaning that they should be debarred from suggesting subjects of investigation as matters of science.

12,001. In reference to your suggestion that they should not interfere of their own motion in any matter within the competency of the Government departments, do not you think that that distinction would not amount to much, seeing that there are so many ways of bringing subjects before the Government in such a form as would compel them to refer them to

W. Spottiswoode, Esq., F.R.S.

14 June 1872.

such a council if it existed?—I think that there might, doubtless, be many ways in which those questions could be made to arise, but that would depend entirely upon the mode in which the council conducted its business, and would not form any part of their general instructions or any part of their fundamental constitution.

12,002. I presume that your objection to the council initiating any inquiries relating to matters within the competency of the Government departments would be, lest any friction should arise between the council and the department?—Quite so; it would be a matter rather of policy than of anything else.

12,003. But if, by the asking of a question in the House of Commons, or in any other way, the Government were placed under the necessity of referring those questions, would it not be the case that that friction would scarcely be avoided?—Certainly; and the means and scope of the council's inquiries would be unbounded, and in whatever way a question was brought before them by the Government, whether willingly or unwillingly on the part of the Government, their course of action would be equally clear and equally imperative.

12,004. (*Professor Stokes.*) When you say that you think that the council should not directly interfere with the administration of the Government, do you go so far as to say that if they thought there was something going wrong for want of a little scientific knowledge they might not represent it to the Government?—Certainly not.

12,005. (*Mr. Samuelson.*) Then the advantage of a council of this kind would reside in this, that it would be able to recommend investigations?—Certainly.

12,006. But it would have this inconvenience, that not quite the same latitude would be left to the Government, if it existed, with reference to the obtaining of a scientific opinion, as if they were at liberty to refer the questions to a committee appointed *ad hoc* or not, as they might judge to be most expedient?—It is quite true that, of course, the Government would be limited by applying to this council for its advice on the subject, but I should expect that the council would very frequently avail itself of members not of its own body, and thus form by itself a committee *ad hoc* upon the subject; I think that all that we can do is to suggest the method most likely to furnish the Government with good information and advice; and that if that council fails in doing that, it fails in one great object for which it was proposed to be constituted; and a failure in that respect would really be a failure of the scheme, a result which, in recommending it, one would not contemplate.

12,007. And, therefore, the question becomes one as between a council of that kind and the appointment of special committees as the occasion may arise?—Special committees might be appointed by the council itself, and I should expect that a special committee would be better appointed by such a council than by the Secretary of State for the department in which the question arose.

12,008. Take, for instance, the committee which was lately appointed on the construction of ships of war, your opinion, then, would be that it would have been better if that committee had been appointed by a scientific council rather than by the First Lord of the Admiralty?—I should suspect that, in the long run, committees would be better appointed by the advice of such a council than independently by the Secretary of State.

12,009. Would you kindly state your reasons for that opinion?—The council would consist of persons conversant with the different subjects of science in which the questions arose; and they would be themselves acquainted, either personally or otherwise, with the men who would be best able to give advice upon the subject, and, even over and above that, I should presume that there would be much personal communication between the ministry and the council, and if the minister in communication had reason to think that he could improve the suggestion of the council, he would have an opportunity of making his views known, and that without in any way interfering with what I should consider of paramount importance, namely, absolute independence of judgment on the part of the council.

12,010. The council would be appointed upon the responsibility of a single minister?—That is a suggestion which has been made, and which I suppose most of the witnesses who have advocated that scheme had ultimately in view.

12,011. Is that your opinion also?—It is. But, as to whether the council should belong to a particular department, while I think it very desirable that all scientific questions should be brought to one focus, I still feel that there is so much connected with the administration of those departments with which one is very imperfectly acquainted, that I feel that my opinion upon that point cannot have great value.

12,012. You have not made up your mind whether the council should be, as it were, a department of a particular minister, or whether it should be a consulting body at the disposal of the various ministerial departments?—That I should apprehend would be in a great measure a question for the ministers themselves to decide. The point which I think should be clear, in the event of the formation of such a council, would be, that it should be the recognised body to which scientific questions should be referred for opinion and advice.

12,013. Then the greatest importance would attach to the first constitution of the council?—Certainly.

12,014. How would you advise the minister to proceed in order to act wisely in that appointment?—I should suppose that he would obtain advice from the leading men of science of the day, and with their advice it would be not difficult to form, at all events, the elements of such a council, although he might not be able at once to complete a very fully organised body. If those first appointments were made, he would have the full advantage of the advice of those members in completing the entire list.

12,015. Comparing the plan of leaving the selection of committees to such a council with the direct appointment of committees by the ministers at the head of departments, you are, of course, aware that if the council were not well constituted, the vice in the constitution of the council would be liable to run through the appointment of all those committees?—Certainly.

12,016. So that there would be a greater risk, in that way, of the committees themselves not being efficient?—The appointment of committees by the Secretary of State of the department is also liable to errors in judgment. I should expect that a council appointed in a way that has been suggested would be as little liable to such errors as any body that could well be formed.

12,017. In fact, that an average council would be as good as an average minister for that purpose?—I should think so, and so much the better, as they are better informed upon the subjects submitted to them.

12,018. Assuming that no suggestions had been made by other witnesses, as to the appointment of such a council, would you yourself have recommended it, or would you have confined yourself to the more limited scheme of more frequented references to such bodies as the Royal Society?—I should have confined my suggestion, in the first instance, to that; but, at the same time, I think it would have been necessary to have some larger scheme in prospect, because, if the Government availed itself largely of that mode of proceeding, the duties would, in all probability, soon become too onerous for the Council of the Royal Society, as at present constituted, to discharge.

12,019. Then, without urging the appointment of the council, as being of immediate necessity, you look upon it, upon the whole, as being a better plan than the mere reference to societies even having the weight and authority of the Royal Society?—I think so.

12,020. (*Sir J. P. Kay-Shuttleworth.*) Looking to the history of the education of our public men, are they more distinguished for high administrative and statesmanlike capacity, or for scientific intelligence and

W. Spottiswoode, Esq., F.R.S.

14 June 1872.

insight?—I should imagine that they are more distinguished for their administrative capacity than for their scientific attainments.

12,021. The question, therefore, to be solved is, how high scientific attainments and insight can be brought as much into the action of the Government as the statesmanlike capacity and experience which you appreciate?—Yes, certainly.

12,022. That, perhaps, might ultimately be brought about by a great change in the education of statesmen, so that they should be at least educated equally in scientific as in literary matters?—I should hope so.

12,023. But, before such a change occurs, so as to increase the power on the part of the central Government to appreciate scientific questions which may be brought before them, you think that some external body having the requisite scientific knowledge and insight should aid the operations of the Government?—I do.

12,024. Whether it be a voluntary body, or whether it be a body having authority and paid for that purpose, is a subordinate question to the necessity of the existence of such a body aiding the Government?—Certainly; what I had in view was, that the question of paying for their services would very shortly become imperative.

12,025. May not many scientific questions, in the present state of things of great importance either to science or to the practical administration of the Government, be put aside for the want of proper scientific appreciation on the part of the Government?—I have no doubt of it.

12,026. For example, if any department of the Government issue a letter giving general and comprehensive objections to the expense of scientific inquiries, would not that seem rather to indicate a want of proper scientific insight on the part of the Government?—I certainly think that the expense of a scientific inquiry ought never to be a complete objection to the undertaking of such inquiry.

12,027. Scientific inquiries may be of two classes, the first class being immediately connected with the wants of some department, say some question which may require immediate solution, lest the Government should make some grave error in the administration of the department. That is a question for the solution of which the Government would obviously, being led by the scientific officers of the department, be induced to pay considerably?—No doubt of it.

12,028. But there may be other inquiries, the importance of which it may require scientific insight to discover, which may not have any immediate consequence on the action of the department, but which scientific men may perceive will have a remote and most important action upon it, and for which it would be incumbent upon a Government having scientific insight to pay largely, but for which a Government not having that insight might refuse to pay anything?—Yes, certainly.

12,029. Do not your answers to these questions render it apparent that a Government which is not aided by the power of such scientific insight must frequently commit grave errors, not merely as to the administration of practical departments, but as to the remote relations of science to the administration?—It appears to me so.

12,030. (*Dr. Sharpey.*) Do you think that the intervention of the Government in affairs of science should be under the direction of a particular department of the administrative Government?—Looking at the question from outside, it appears to me that it would be a great public convenience that it should be so; but, as I stated before, there may be reasons of internal economy and administration which might interfere with such a conclusion.

12,031. Do you not think that a moderate measure might be to appoint a permanent under secretary conversant with matters of science, and at the same time of administrative capacity, to be in communication with this council, and to preside at the council if necessary?—I think that that might be a very convenient arrangement.

12,032. Because, in the case of appointing committees, and the like, I suppose you do not mean that the consultative council should have absolute power to employ committees for special objects, but that they would inform some minister or under secretary of their opinions on the matter, and he would decide the question?—I quite contemplated that it would be the function of the council to nominate such committees and the actual appointment, together with the funds placed at the disposal of such committee, if it involved investigation, would be in the hands of the minister.

12,333. At present, when the minister of any department appoints a committee, his selection is entirely through private information, is it not?—So I understand.

12,034. Whereas, in the case of a council such as is contemplated, that probably would be done on a report which might be produced before Parliament if required, and it would be seen on what authority the minister had proceeded in making the selection?—Certainly.

12,035 Do not you think that that would be preferable to the present system of exercising his private judgment or acting on private information?—I think that it would be both better in itself, and also I think it would go far to gain the confidence of the country at large. At present, when any question of this kind arises, especially when a large part of the community are directly interested in its issue, some dissatisfaction occasionally undoubtedly arises from the fact of it not being apparent to the public in what way those questions are decided; and I think that the fact of there being one recognised channel of information, or one recognised mode of procedure, would go far to gain the confidence of the public, and, on that ground, the suggestion might strongly recommend itself to the public mind.

12,036. (*Mr. Samuelson.*) How would you deal with matters of mixed administration and science; would you suggest that the council should, in those cases, be called upon to name only the scientific members who might co-operate with the members named from other considerations?—Without laying down any regular rule beforehand, I think that it would not be difficult to solve the question in some such way as you suggest.

12,037. (*Chairman.*) May we conclude that you consider that any permanent arrangement of the nature that we have been talking about could hardly be arrived at at present, and that it would be necessary, in the first instance, to make some provisional arrangement, if anything of the kind is attempted?—I think that it would be quite necessary to make some tentative arrangement to begin with; but, at the same time, I should be sorry that any such attempt was made without having some more complete scheme distinctly in the mind of those who recommend it.

12,038. If such a consultative council were appointed, you would probably contemplate that it would be mainly composed of persons now to be found on the council of the Royal Society, or on the committee of recommendations of the British Association?—Yes, I should imagine that it would be mainly composed of Fellows of the Royal Society.

12,039. How would it work if there were some arrangement by which the council of the Royal Society should propose a certain number, two or three persons out of whom the Government might select one on any vacancy?—I see no objection whatever to that proposal.

12,040. That would secure, as a general rule, the appointment of persons of the highest scientific qualifications on the council?—I think it would.

12,041. Is there any addition which you would like to make to your evidence?—I am not aware of any other point.

The witness withdrew.

Adjourned to Wednesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 19th June 1872.

PRESENT :

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

PHILIP LUTLEY SCLATER, ESQ., M.A., PH.D., F.R.S., further examined.

P. L. Sclater, Esq., M.A., Ph.D., F.R.S,

19 June 1872.

12,042. (*Chairman.*) I believe you are acquainted with the plan recently put forward by Colonel Strange for the better organisation of science?—Yes, I am acquainted with it to a certain extent.

12,043. Do you agree with his views as to the creation of a minister of science and a council of science?—Yes, I agree generally with his views; I think that it would be very desirable for the interests of science.

12,044. Do you think it would be desirable that the existing State scientific institutions should be removed from the control of the Admiralty, the Office of Works, and other departments under which they are now placed?—I think it would be a very great advantage that they should be removed from those departments and placed under one minister.

12,045. Have you any opinion as to whether the work could be done by a minister of education, supposing such a minister were appointed?—I think it would hardly be expected that a minister should be appointed only for science; and as I believe it is the case in continental countries that that department is given to the minister of education, I think that we could not follow a better example here.

12,046. Have you formed any opinion as to the constitution of a consultative council to assist this minister?—My idea would be that the heads of the different scientific institutions that are put under the control of the department of science and the minister of education might form a consultative body and be called a council of science, and that there might be certain other members added to assist them in deliberation, if it were thought necessary, such as representatives of the College of Physicians, the College of Surgeons, and of the scientific branches of the Army and Navy.

12,047. Colonel Strange's proposed council would consist of 30 members at least; do you think that that would be too numerous a body?—I think that a less numerous body might suffice, because I see that, in many cases, however numerous the body was, it would be necessary to call in special assistance.

12,048. Colonel Strange recommended that the members of the council should receive a considerable salary, what would be your opinion upon that point?—I am quite in favor of paying scientific men handsomely, but I think that we must consider what would be acceptable to the country generally; and I think it would suffice, perhaps, to pay them a moderate salary. And if the plan that I suggest were adopted, of using the heads of different institutions as a consultative body, then a moderate addition to their salaries in consideration of their sitting as members of the council of science would, I think, be sufficient.

12,049. If a council were constituted in the manner that you propose, should you contemplate that, as a rule, they would be capable of giving advice themselves on most questions that would arise, or would they generally find it desirable to call in further assistance?—I think that, in most cases, they would be quite competent to give an opinion to the Government; but that sometimes, on particular questions, it would be necessary to go elsewhere for advice; and that, in such cases, there would certainly be somebody in the council who would know exactly where to put his hand upon the right man for the purpose. For instance, a question might arise in some special department of Natural History: in that case, the council would naturally refer to the head of the State Museum of Natural History to know if he could give an opinion himself, and if not to inform them who could give an opinion upon the point. Thus, I think that with the aid of a small council of science of, perhaps, 20 members, every question requiring solution by the Government as regards science might meet with very fair consideration and be very easily settled.

12,050. Could you enumerate the members of an efficient council, supposing it to be constituted in the manner you think desirable?—I have no detailed list prepared of them; but I should say, the Astronomer Royal, the head of the British Museum—not the Principal Librarian—but supposing, as I do, that the Natural History Department will shortly be removed from the British Museum, the head of the Natural History Department would be the proper representative of Natural History for the country, then the head of the College of Chemistry or other leading chemical institution which the Government choose to have, the Director of the Royal Gardens at Kew, the Warden of the Standards, and, in fact, the heads of all those institutions which Colonel Strange proposes to unite under one rule.

12,051. Have you contemplated new institutions being formed, as well as a new council?—If any perfect scheme is to be made for the advancement of science in this country, there certainly must be new institutions formed. If I understand rightly, at the present moment there is no institution for general astronomical work. The whole of the work of the Royal Observatory at Greenwich is done with a special object, and not done for the extension of astronomical science generally. That would be one instance in which a new institution, or an extension of existing institutions, would be required.

12,052. But, supposing it were desirable to constitute a council of this nature, but not, at present, to establish any new institutions, do you see any means of forming a satisfactory council to assist the Government?—I think that, taking even the institutions that now exist, the heads of them, with a few additions from other learned bodies, would make a very good council of science, and they would be able to recommend such further extensions of existing institutions as are necessary.

12,053. It might be one of the first duties of such a council to advise the Government as to any new institutions which were imperatively needed?—Certainly, one of the very first duties.

12,054. Have you any misgivings as to whether such a council would command sufficient public confidence amongst men of science?—I have no misgivings at all upon that subject. I should say that they would meet with general support from men of science. Most men of science, I think, see that something of the sort is imperatively required. All lament the piecemeal way in which scientific subjects are dealt with by Government, in consequence of their being subdivided amongst all these different offices, and of there being nobody to appeal to upon a question of science, and, therefore, I think the proposal to establish such a Council would meet with universal acceptation amongst scientific men.

12,055. Would you propose that this council should draw up an annual report?—I think that that would be one of the very great advantages which we should derive from amalgamating those institutions under one rule. At the present moment, it is difficult to know what is going on at the different scientific institutions.

P. L. Sclater, Esq., M.A., Ph.D., F.R.S.

19 June 1872.

The report of the Director of the Royal Gardens at Kew is published in one way, that of the British Museum is mixed up along with the Civil Service estimates, and so on. But if there is a council of science established, of course it would be part of their duties to prepare a report upon the progress made by the whole of the different scientific institutions under their care. That, I think, would be a document which would be taken in by all scientific societies, and be universally circulated amongst scientific men, both in this country and abroad, and it would be a very valuable report.

12,056. Have you formed any opinion as to what would be the most desirable tenure of office of the members of the council; those that are mere *ex officio* members would, of course, be members so long as they held their posts, but as to the other members of the council, do you think that they should hold office for life or for a term of years, or on what conditions?—I should say that a considerable term of years, with a possibility of re-appointment would be most desirable, say 5 or 10 years.

12,057. (*Dr. Sharpey.*) Do you think that a mode of settling the payment which would be practicable and also tentative might be to pay the council for their meetings, so much a meeting?—I know that that is the plan adopted in certain railway boards and bank directions, and I believe it has worked well, and I do not see why it should not be imitated in a council of science.

12,058. Do not you think that it would be difficult to settle beforehand what ought to be the recompense for a gentleman, serving on that council, for his time; it would be very difficult to know to what extent his time would be occupied?—Certainly.

12,059. Whereas, by remunerating him according to the time that he gave up to the duty, perhaps the Government would eventually come to learn what would be really needed?—Yes, I think that that would be an advisable experiment to try. At the same time, I anticipate that the members of the council of science would do a great deal of work, not when they were actually meeting at the board, but away from the board, and that it would be difficult, perhaps, to measure the extent of that work.

12,060. Even in the way of reports; for example, a leading chemist might be called upon to give a report upon some subject, and the work might take him weeks or months. But even in the case of a fixed salary, you would have some difficulty, because some members would be more employed in extra work than others?—Yes, certainly.

12,061. So that, in any case, it would not be very easy to fix at the outset what ought to be a suitable remuneration?—Just so.

12,062. On the whole, you think that the payment according to the number of meetings, perhaps, might answer the purpose?—Yes.

12,063. It would be somewhat analogous to the case of the Medical Council, who receive a fee for each meeting?—Yes, that is supposing that the Government were to allot a gross sum for the council of science generally, and then were to leave the members to distribute it amongst themselves in such a way as they thought just.

12,064. Perhaps, under the guidance of the minister of science of whom you spoke? Do you think that that minister of science should be at the head of a new department with the rank of a secretary of state, or might he be a permanent under secretary of state in some existing department, charged with the special duties that you would assign to him?—My impression is that the working man would be a permanent under secretary, or in some position of that sort. I think it would be very objectionable to have a political person employed except as the Minister.

12,065. The head of the department, of course, could reply to questions in Parliament?—Yes, exactly so.

12,066. (*Professor Stokes.*) In the case of the unofficial members of the council, do you contemplate that the Government would have the command of their services when required?—I do not quite understand whether by unofficial members you mean such a person as the nominee of the College of Surgeons.

12,067. I mean all who are not members of the council by virtue of their Government appointments?—I think that such members ought to be paid such a salary as would satisfy them to become members of the council of science. I suppose that the Government could not force anybody to become a member of the council of science, but that they would make such a person an offer and he would know what salary he would receive for acting as such.

12,068. Should it be one of their duties to attend any meeting at a few days' notice, or merely to come when they could manage to make it fit in with their other engagements?—I think it ought to be of primary importance that they should attend imperatively, unless with some reasonable excuse.

12,069. If the attendance there were absolutely imperative, would there not be considerable difficulty in making it fit in with their private professional engagements?—I think that there would be some difficulty in that respect; but I think that the position of a member of the council of science would be looked upon as so honourable, and so advantageous, amongst scientific men, that a man would make any sacrifice who held the position to attain to it and to keep it, because he would certainly be considered the representative in England of his particular branch of science. I look upon it that the members of the proposed council would all be first-rate men—it would be seen at once that they were leaders of their particular departments—and that they would do all that they possibly could to fulfil their duties.

12,070. You anticipate that those members who are connected with institutions in the country requiring their services at such and such times would get leave of absence from those institutions?—Yes.

12,071. Those requirements would be dispensed with?—Yes, because I think it would be considered of paramount importance to attend the meeting of the council of science, and to advise the Government upon these important subjects.

12,072. Have you formed any opinion as to the probable frequency of the meetings of the council?—I have not formed any very definite opinion, but I do not think it would be necessary that they should meet very constantly. I think at first, perhaps, while the organisation of the scheme was going on, frequent meetings would be necessary, but I fancy that a great deal of the work would be done by the individual members, perhaps in the shape of committees of one or two, or even, in particular branches, by the head of that department of science, and that the reports of this work would be given to the board when they met twice a month, perhaps, or so, and that the work might be carried on very easily in that way without requiring very constant attendance at the board.

12,073. Then I understand that you regard the duty of the council not so much to be to meet for the purpose of general deliberation, and, as occasion arises, of portioning out the work amongst those who are best able to do it, as to take the greater part of the work upon themselves?—The council would be composed principally of the heads of the great scientific institutions, who would be responsible for the whole of the work done by the institutions under their care, so that all of their time would be occupied with objects of a cognate nature to that which they discussed in the council of science. Thus, the greater part of the work that was brought before the board would, I fancy, be done away from the board, but be brought before it in the shape of reports.

12,074. Then, in the case of investigations which were required to be undertaken, how do you conceive that they would be dealt with?—I should say that the member of the council representing the particular branch of science would be called upon to present a preliminary report of how he proposed to set about any particular investigation. He would say, To do this I shall require the assistance of such and such

P. L. Sclater, Esq., M.A., Ph.D., F.R.S.

19 June 1872.

persons for so many days, or for such and such time, or to send here or to send there, and would bring these requirements, in the shape of a preliminary report, before the board, and, if this were approved, would carry out the investigation. Then he would present his report upon the result of the investigation, and the council, as a body, would consider it, and recommend its adoption by the Government or otherwise.

12,075. Then, do I understand that you would prefer, as a general rule at least, that the members of the council should themselves carry out such investigations as might be required from time to time, rather than that they should merely indicate to the minister the person, outside the council very probably, who they thought was best competent to carry out the investigation?—I do not think it would be necessary to draw a hard and fast line upon such a question as that. I think that in many cases it would be better that the council, as a whole, should report to the Government on the best way in which any particular scheme might be carried out. I do not think that it would be necessary to introduce a rule that you should invariably go to the member of the council representing that particular science if advice were wanted upon that branch. But the council would naturally turn to the representative of the particular science for an answer; they would naturally look to his advice first.

12,076. I understand you to mean that the duty of the members of the council should be to know where to go in order that particular questions should be answered, whether it were to go outside the council or to go to one member of the body?—Yes, that is my opinion.

12,077. In case investigations were undertaken at the request of the council by a person outside the council, would you contemplate that there should be any pecuniary remuneration?—Certainly. I think you could hardly ask a gentleman to devote his time to the service of the Government in that way without paying him for it.

12,078. Supposing it happened that the most fitting person to undertake such investigation were one of the members of the council itself, where it was an investigation involving the expenditure of a great deal of time over and above the ordinary duties of that member of the council, would you, in that case, think that he ought to get an additional remuneration?—I should say that, as a general rule, it would be unadvisable to allow that; but, of course, under special circumstances, perhaps, by a special application to the minister of science, that might be granted. As a general rule, I do not think that it would be advisable, because I think that the members of the council of science ought to receive a fixed salary as payment for devoting the best of their abilities and time to their duties as councillors.

12,079. The best of their time even in the case of unofficial members?—I think so. I think that it would, perhaps, be thought objectionable that the members of the council of science should be finding work for each other in that way, if I may so say.

12,080. But might it not happen that the very fittest man in the kingdom to carry out one of those investigations might be a member of the council?—Very likely indeed, I should say.

12,081. In that case, supposing the question of any additional remuneration rested entirely with the minister who was at the head of the department, do you think there would be any liability to that abuse, considering that the members of the council, as the heads of science in the kingdom, would be, as we may hope, men of unblemished honour?—I think that it would be objectionable, as a general rule, to pay the members of the council more than their fixed salaries. I think it would be objectionable, looking to what the public would think of it in general.

12,082. In answer to Dr. Sharpey, who asked you about the plan of payment by attendance, you rather approved of that plan, did you not?—I am now a little doubting about it. I think that it would be more satisfactory that each member should receive a fixed salary.

12,083. (*Sir J. P. Kay-Shuttleworth.*) I gather, as a summary of your evidence, that you consider that the scientific council should consist of men of pre-eminent scientific knowledge of some particular department of science, but likewise having a familiarity with the modes of scientific investigation, as well as a general acquaintance with the qualifications of scientific men, and, therefore, power to select men competent for any special investigation?—Certainly.

12,084. But, besides this, there is the function, which you have likewise described, of advice to the Government as to the application of scientific laws to the practical operations of the Government. That would involve that there should be upon this council some men of considerable administrative experience?—I am not quite sure whether you mean belonging to the department of the Government which required advice.

12,085. I do not mean that in particular; whether they were connected with the department of the Government requiring advice or not might be questionable, but that, in the application of scientific laws to practice, there should be on the council men having administrative experience?—I think that the heads of great scientific institutions must have administrative experience. If a man has to manage an institution like the Royal Observatory at Greenwich or the State Museum of Natural History, he must have the command of a great many men under him, and must be acquainted with the business of the institution, and must have gained his administrative experience. He could not fail to be a person of administrative experience.

12,086. But, taking the application of scientific laws to specific departments of the Government, the army and navy, for example, would it not be important that there should likewise be on the council some men of special knowledge of the mode of facilitating the adaptation of scientific laws to those departments?—I think, certainly, that the army and the navy, which are the branches of the service, perhaps, most requiring scientific assistance, should be represented by one or more members at the board, and no doubt the Government would take care to secure a first-rate man for what I should consider a post of the very highest honour.

12,087. But, speaking generally, however eminent their knowledge might be of any particular branch of science, or however eminent their general knowledge of science and of scientific men, they should be men also characterised by having administrative ability?—I apprehend that no scientific man would be appointed to the head of a large Government institution unless he was a man of administrative ability, at least, I hope that such would not be the case, and, therefore, by taking the head of these particular institutions you would get men of administrative ability on the council of science.

12,088. And it is in that way, you conceive, that you can provide for the particular qualifications to which my questions advert?—I think so.

12,089. (*Chairman.*) I think I understood you to say that the council, as you recommend it should be constituted, would probably consist of about 20 members?—My impression is that about 20 members would be sufficient, but I have not gone into any details upon the subject.

12,090. I see that you recommend that there should be nominees of the leading scientific societies, can you give the Commission any idea of how many societies would properly come under that denomination?—Of course, if that part of the scheme were carried out, it would be necessary to draw up an account of the scientific societies in this country, and to pick out representatives of each branch of science; but I have not given any detailed consideration to that part of the scheme.

12,091. It would be necessary to take into consideration the scientific societies in Scotland and in Ireland, as well as in England, would it not?—I think not

P. L. Sclater, Esq., M.A., Ph.D., F.R.S.

19 June 1872.

necessarily, because I apprehend that there are societies in London filling nearly every vacancy in the field of science, and certainly if the board, as I apprehend it would, met in London, it would be better to have persons resident in London than in Dublin or Edinburgh or elsewhere.

12,092. From what we know of the feelings of Ireland and Scotland on kindred subjects, do not you think that there would be a great outcry if there were not some members of the council who were considered to be representatives of Scotland and Ireland?—Yes; I think that might cause an outcry; at the same time, I may say that there are a great many Scotch and Irish eminent representatives of science in London.

12,093. Would not the colleges of physicians and surgeons, both in Scotland and Ireland, probably expect to be placed on an equality with the London colleges of physicians and surgeons?—Yes, I think they might fairly claim to be so.

12,094. If the council were constituted on this system, would there not be considerable difficulty in keeping the numbers within moderate limits?—I think there would be; but I consider that the main body of the council should be constituted from the directors of the Government scientific institutions, and that the other alternatives should only be taken into view to fill up the numbers, in fact.

12,095. How far do you think that the object might be accomplished by a much smaller council, not consisting, at the outside, of more than 10 to 12 members selected by the Government?—I think that it would not be advisable to have a larger council than was absolutely necessary. I believe that a small body of men generally work better and do more work than a large body; but I do not think that 20 would be a very large number.

12,096. (*Professor Stokes.*) In case the council were smaller in number than you at first contemplated, do you think it would be a good plan that they should occasionally invite other scientific men to appear as witnesses, or that they should request their advice at a personal interview?—I think that that would be an excellent plan, certainly. I may state that I think that the council of science should be as small as is compatible with the representation of every branch of science; the great object is to have at least one representative of each distinct branch of science. You may make it as small as you can, but do not omit any important branch.

12,097. (*Chairman.*) On a former occasion you made some suggestions for the improvement of the Natural History Department of the British Museum, are there any other recommendations which you would wish to offer, bearing on the same subject?—There is one point which Colonel Strange alluded to in his evidence, and that is the importance of attaching naturalists to every surveying vessel sent out by the Admiralty, or, indeed, to every ship sent out on a distant voyage, so far as it can be done without detriment to the service.

12,098. Nothing of the kind is at present done systematically?—Nothing of the sort is done systematically. It is occasionally done, if there is an application made, but it is very difficult to get such applications attended to. I may mention that when the Abyssinian Expedition was planned, nothing of the sort was contemplated by the Government in England, although the Indian government sent out a geologist, and it was only by the Zoological Society of London making an application, first of all to the India Office and afterwards to the Treasury, that leave was obtained to send out a naturalist with the expedition. Even then, the Government refused to pay the naturalist any salary, but said that they would find his expenses, and I am not sure that so much would have been obtained had it not so happened that the Secretary of the Zoological Society was personally acquainted with the then Chancellor of the Exchequer, and managed to obtain a private interview, and was able to force his views upon the Government in that way. I only give that as an instance of the difficulties which are often met with. On our first applying to the India Office, we were told that we must go to the Treasury.

12,099. You recommend that a naturalist should be attached to every surveying vessel as a matter of course?—I think that would be certainly the right thing in the case of a surveying vessel which is employed for months and often for years on the same line of coast, continually sending boats out to the shore—one naturalist or more should be attached to such a vessel.

12,100. Would that apply to vessels under the Hydrographical Department of the Admiralty?—Yes, I apprehend so.

12,101. You think that a place might be found for a naturalist in all such expeditions?—I think there is no question that that place ought to be found.

12,102. Are there any other undertakings, under the auspices of the Government, to which you consider that naturalists might be attached with advantage?—At the present moment I believe that there is an astronomical expedition being fitted out for the observation of the approaching transit of Venus, and that, in order to carry the observations out satisfactorily, there will be temporary observatories established upon three islands in the Pacific, which are all very little known. Of course the Astronomer Royal, when he was consulted as to the institution of these expeditions, never considered that it was part of his business to connect natural history with them, or to have a staff of zoological collectors; yet, if the astronomers have a place of residence on these islands for a year or more, the addition of a naturalist or two to such expeditions would cause very little additional cost, and might give rise to very extensive discoveries, and be the means of providing the Government Museum of Natural History with a large number of valuable specimens. Nevertheless, owing to its being no one's particular business to advise on such a subject, the probability is, that, unless it is taken up by some independent body, such as the British Association or some of the learned societies, nothing of the sort will be done. If there were a Scientific Council sitting, of course, when the Astronomer Royal brought forward his plan of establishing observatories in such and such places, the leading naturalist would immediately point out that these were places where investigations ought to be made in Natural History, and would request the council to take the opportunity of sending naturalists out to them.

12,103. Might not this object be sufficiently attained if it were generally understood to be a very proper proceeding on the part of the learned societies, or the British Association, to make representations to the Government on such occasions?—I am afraid it is a case of what is everybody's business is nobody's business, and that the scientific societies will not always take the trouble to do it.

12,104. When naturalists have been attached to surveying vessels, what have become of the collections which they have made?—In many cases they have been deposited in the British Museum; but this has not always been done; they have been given frequently to private collectors and private institutions, and no sufficient care has been taken that such collections should be all sent to the British Museum.

12,105. Do you think that, as a general rule, everything should go to the British Museum?—I think certainly it ought; but before going to the British Museum, I think that a report should be drawn up and published of the collections made during the expedition, so as to convince the public that something has been done, and that good use has been made of their money, and, at the same time, to show the discoveries that have been made by means of the expense that has been incurred. I may mention, for instance, that the Indian Government, about two years ago, sent an expedition to explore a new trade route from British Burmah to Yunnan in China, and that they appointed a naturalist, Dr. Anderson, a man of well-known acquirements, to accompany it, and that Dr. Anderson spent a large sum of money in collecting,

P. L. Sclater, Esq., M.A., Ph.D., F.R.S.

19 June 1872.

and also in having very beautiful drawings made of the new objects which he had collected. But when he got back to Calcutta, the Indian Government refused to go on and give him any assistance in publishing his discoveries. The consequence is, that they have never been published up to the present moment, except certain portions of them that Dr. Anderson has published through the means of the scientific societies. For instance, the Zoological Society of London have published one or two of his papers, containing an account of some of the finest things that he got.

12,106. (*Sir. J. P. Kay-Shuttleworth.*) Do you think that that arose from a want of appreciation of the importance of the results which you think should have been published, or from any other difficulty on the part of the Government?—I think that it arose from the fact that the Indian Government were short of money at the time, and that they did not sufficiently appreciate the importance of Dr. Anderson's discoveries. I suppose that 500*l.* would have done everything that was necessary.

12,107. May that be taken as an example of the want of scientific knowledge and scientific insight on the part of Governments which are not advised by a scientific council?—That is exactly an instance that I should give. I may state that Dr. Anderson sent the whole of his drawings to me, and that I looked them over very carefully. I wrote to the India Office on the subject, to Mr. Grant Duff, and strongly urged upon him the importance of having them published.

12,108. The Government has upon it great and pressing demands for the ordinary wants of the administration, for war, for the extension of railways and irrigation, canals, and general public improvements throughout the country, and unless it happens to have a scientific insight into the immediate or remote results of scientific investigations, it is not likely to spend much public money upon such objects?—Exactly so. But what I complain of is, that they should have sent Dr. Anderson out at all if they did not intend to let him show what he had done, and that he had spent his money well, by publishing the results. If they had not intended to publish the results, they had better not have sent him out.

12,109. That showed a want of continuity of action on the part of the Government: they obeyed the impulse of, probably, one single individual, who was removed to some remote station, and then, not having that impulse permanently in their body, they ceased to act?—Yes; and such errors, I think, would be remedied by the creation of a council of science.

12,110. (*Chairman.*) Do I understand you that the decision in Dr. Anderson's case was come to by the Indian Government in India?—That I really cannot undertake to say. I believe that the Government here said that the publication must be done in India, and that the authorities in India said that it must be done at home. I can give another instance. Many years ago there was a very celebrated expedition to the Antarctic Seas, of which Dr. Hooker was the naturalist. He was sent round the world, and collected a large quantity of materials, and there was a sum of money given by the Government to publish the materials. That money was expended, and yet the publication was never completed, and remains incomplete to the present day; so that, even when money is given, there is no due supervision exercised to see that it is properly spent, and that the results that ought to be produced are produced and given to the world.

12,111. (*Professor Stokes.*) Has there not been a partial publication of them?—Yes, there has been a partial publication of the voyages of the "Erebus" and the "Terror;" the botany (of which Dr. Hooker himself undertook the publication) is finished, but the zoology has never been finished.

12,112. Is the reason of that that the sum granted was insufficient for the publication of the whole?—I do not know what the reason is. I apprehend that that would be stated as the reason if inquiry were made.

12,113. (*Chairman.*) No one has either felt sufficiently interested in the matter, or has had sufficient influence to get the work completed?—No.

12,114. You recommend that all collections made under such circumstances should be sent to the British Museum. Would you think it desirable that the British Museum should, as a rule, retain all such collections, or that they should be the medium of deciding where they should ultimately be deposited?—I think that if the British Museum did not want them they might very well part with them to other scientific institutions; but a register should be kept of where they have gone to, so that they should be comeatable in case they were wanted.

12,115. At present, everything that goes there is kept there for ever, is it not?—I believe that is the general rule of the institution, and I think that the reason why there has been an indisposition to give specimens to the British Museum has been partly caused by the fact that it is so very inconvenient to work at them after they are there. The rule of the British Museum is that when an object goes in it shall not come out again; therefore, if once objects are deposited there, naturalists are not able to get them out again to work at them and describe them properly. For this reason there is always a disposition rather to keep specimens in private hands, in order that they may be more easily got at, or to give them to other institutions where they can be moved again for the purpose of being worked at.

12,116. (*Professor Stokes.*) Is it not possible to work at them in the museum itself?—I should say, under present circumstances, it is barely possible; the want of space is so great, and there is no proper working place.

12,117. (*Dr. Sharpey.*) Do you expect that in the new building there will be sufficient provision for all that sort of work?—I hope so. I should say that it was one of the most important additions that could be made.

12,118. Are you sufficiently acquainted with the arrangements intended in the new building to be able to say that there will be sufficient accommodation provided for that work?—I am not able to say whether it will be so or not.

12,119. (*Chairman.*) Have you reason to believe that any Government collections have been altogether lost?—I know that some of the specimens collected by Mr. Darwin during his well-known voyage round the world cannot be found now, they are lost in fact. They were not sent to the British Museum but to the Zoological Society of London, who had a museum at that time, and others were left in private persons' hands, and cannot be found. I have had occasion to refer to some of them myself, but I have not been able to find them.

12,110. The Zoological Society's Museum was entirely dispersed, was it not?—Yes, it was.

12,121. Were any particular parts of it transferred to the British Museum?—The first offer of the whole was given to the British Museum, and, if great care had been taken, all the valuable specimens might have been selected and taken to the British Museum, but sufficient care was not taken, and, in consequence of that, I believe a great number of objects have been lost.

12,122. From what sources are the zoological specimens of the British Museum chiefly obtained?—I think I may say that they are chiefly bought of dealers in natural history; and that I consider is one of the great defects in the present zoological collection of the British Museum. It is impossible to say from what particular locality a certain specimen has been derived. Knowledge of locality is now considered, and quite rightly so, one of the most important elements in zoological science. Since the laws of distribution have been so fully studied, as they have during the last 30 or 40 years, it has come to be quite a feature in a specimen; you want to know exactly where each specimen of an object was obtained, or you are not able to draw deductions from it as to variation, and many other important questions. With regard to a

P. L. Sclater, Esq., M.A., Ph.D., F.R.S.

19 June 1872.

specimen purchased of a dealer, &c., he very often destroys the label which was originally attached to it, and then there is no certain knowledge of where it is obtained, so that specimens obtained from an original collector are very much more valuable than those purchased of dealers.

12,123. Are you aware whether any of the large dealers employ collectors themselves, or do they trust to accident?—They do not employ collectors, but often assist collectors by advances, and receive collections from them. But the dealers will not take care when they receive specimens from collectors that the localities are properly kept, they mix the specimens together coming from half a dozen different countries, so that if you buy a specimen from a dealer you are never certain as to whom it was collected by.

12,124. They are guided more by commercial considerations than by scientific considerations?—Exactly so.

12,125. Can you suggest any addition which you think of importance to the staff of the Natural History department of the British Museum?—Supposing the plan is adopted of sending collectors out with the different surveying expeditions and other expeditions, it would be very desirable that these collectors should first of all pass a certain part of their time at the State Museum of Natural History, and be instructed in the best mode of preparing specimens of all sorts, and in the wants of the museum, and as to the particular things that they ought to look for at each particular place that they are going to. I should suggest that three or four assistants should always be ready at the museum to be sent out with the different surveying expeditions whenever they are required; or they might be sent out for a year or two, and then return to the British Museum. In this way they would have time to arrange and describe their specimens; and they might take another turn out in another surveying expedition, if they felt inclined to do so.

12,126. Is there any system of the kind in operation at the Jardin des Plantes?—Yes, in the Jardin des Plantes they have had many well-known zoological and I believe botanical collectors, some whom I have known personally myself, and many of the most valuable specimens in the Jardin des Plantes at Paris have been obtained by these collectors. Of course it is always very satisfactory when one is looking at a specimen to see a well-known name upon it, and a certain locality. The late M. Alcide d'Orbigny was one of the most successful of those collectors. He made a celebrated voyage to South America, and went into Bolivia and other out of the way countries. To each specimen collected he attached his name, and the exact locality where he collected it. Thus, you may be sure that each specimen was found by him at a particular date and in a particular locality. At Vienna, also, the Imperial Austrian Cabinet has employed collectors, and sent them round the world. But I am not aware that anything of the sort has ever been done by the British Museum up to the present time.

12,127. Are there any other points upon which you wish to make additions to your evidence?—I should wish to say, with reference to another part of Colonel Strange's evidence, which I have since read, that I think it would be very desirable that the Government should grant rather more assistance, than it has hitherto done, to the different scientific societies of the metropolis, in the way of providing rooms for them. There can be no doubt that we are mainly indebted for our scientific reputation as a nation to the efforts made by our scientific societies, particularly those of London. I think nothing can have answered better for the promotion of science than their efforts, and it would be a very fair thing to do, if assistance could be given to them in this way. I would not wish to put them under Government control in any way, but I think that more assistance might be given to them in the way of finding house accommodation, particularly in the case of some of the poorer societies. That would be a subject well worthy of the consideration of a council of science, should such a council be constituted

12,128. Does the Zoological Society receive assistance in any shape from the Government?—None at all, but I think that the Zoological Society, from having their gardens to draw upon, are quite able to take care of themselves.

12,129. Financially they are, perhaps, more prosperous than any other society?—Yes, I believe I may say so.

12,130. Do they pay rent for the garden?—Yes.

12,131. Is it a full rent?—Looking to the enormous revenue which we get from it, we do not pay a full rent, but we pay quite as much rent as any other use of the land would provide, that is to say, we pay the same rent as the land occupied was formerly let at for grazing purposes, I believe.

12,132. Several societies are provided with apartments, are they not?—Yes, they are; but I do not know that any particular rule has been observed. Some of them have been successful in getting Government assistance in that way, while others have not been successful.

12,133. Do you think that, as a general rule, most of the more important scientific societies might properly be provided with apartments?—I think it would be a very proper thing to do.

12,134. Would you grant them assistance in any other shape, as, for instance, in the publication of their transactions or their proceedings?—I am not prepared to give a very definite opinion upon that point, but I think it would be very desirable that they should be furnished with accommodation for their meetings.

12,135. (*Sir J. P. Kay-Shuttleworth.*) Supposing that the museum were transferred to some place which afforded sufficient facilities in point of building and arrangements, would you consider it desirable that there should exist a machinery for the dispersion of specimens, and for their scientific arrangement in local museums for the purposes of general instruction in the country?—I think that, supposing these plans were carried out for attaching naturalists to different expeditions, there would be an accumulation of specimens in all the branches of zoology, and that no better use could be made of them than, after comparing them and naming them and arranging them according to the system of the British Museum, to transfer them to local museums.

12,136. For that purpose you have no existing machinery?—There is no existing machinery for that purpose.

12,137. It would become necessary to create such machinery, provided all the preliminary arrangements were satisfactory?—Certainly. At the present moment, I am speaking more particularly of zoology, with which I am best acquainted, the staff is miserably insufficient at the British Museum; there is not nearly a sufficient staff at present even to arrange what is already there, without collecting anything fresh.

The witness withdrew.

J. D. Hooker, Esq., M.D., C.B., F.R.S.

JOSEPH DALTON HOOKER, Esq., M.D., C.B., F.R.S., further examined.

12,138. (*Chairman.*) I believe you have had an opportunity of acquainting yourself with the plan put forth by Colonel Strange for the establishment of various scientific institutions under the Government, and also for the creation of a department of science and a council of science: are you prepared to give an opinion upon any of those proposals?—I have given the proposals the best attention that I have been able during the very short time which they have been in my hands, but I have of late been so occupied with other matters that I could not give the subject that attention which I could wish; there are, however, several points upon which I might have a few words to say. I think, in the first place, that the general proposition is an

J. D. Hooker, Esq., M.D., C.B., F.R.S.

19 June 1872.

excellent one, that the Government should be aided by scientific persons, both with respect to the administration of the existing Government scientific institutions, and with respect to the occasional grants which the Government may be called upon to make for scientific objects; but with regard to the way in which this aid should be given, it is a very difficult question, and, as far as I am aware, it is entirely a new one. With regard to the scheme that Colonel Strange proposes, the principal objection that I see to it is its magnitude, which makes me doubt whether it will be possible, under the present condition of science in this country and of the scientific institutions, to get the Government to entertain the view of constituting a body so extensive, and armed with powers which must interfere with the authority and responsibility of the ministers of the Crown. There is, however, an alternative which may be more practicable, and that is, that the several departments of the Government charged with the administration of scientific institutions, should each have a body of scientific advisers; in other words, that the different Government institutions should have, as the Royal Observatory at Greenwich has, a board of visitors, a consultative body, whom the Government might apply to in cases of difficulty in the administration of the institution, or of any extraordinary expenditure being demanded for it, and whom the director of the institution might consult in case he has any difficulty in carrying out his duties.

12,139. Do you know by whom the Board of Visitors of the Royal Observatory is nominated?—Not precisely.

12,140. Are the appointments permanent?—I am not prepared to go into that subject.

12,141. They are not paid officers, are they?—I believe not.

12,142. Would you contemplate that such boards as you recommend should generally be unpaid?—I think that they should be paid upon special occasions, but not by fixed salaries. For instance, occasions would arise when the Government required prolonged attendance, and valuable reports requiring a great deal of time and a great deal of skilled labour; and in such cases some, or all, of the members should be remunerated. But there are many matters upon which the Board's opinion could be given with very little time or trouble, and which they would give in the interests of science.

12,143. Have you in your mind the appointment of several such boards of visitors?—My suggestion would be that each of the scientific institutions under the Government should have such a body of visitors.

12,144. How would you propose that the Government should get advice on scientific questions not connected immediately with any of those Government institutions? — By convening a selection from the various boards of visitors, with, perhaps, the addition of experts.

12,145. You mean selected for the special occasion? —Yes.

12,146. You do not contemplate that there would be any serious difficulty in constituting such councils in a manner to give confidence to persons engaged in the various departments of science?—I see no difficulty in that. It would depend upon the wisdom and discretion exercised by the Government in the selection.

12,147. But does it necessarily follow that they would have more confidence in such a body than in the Government?—I think so, from the very fact of the Government not being scientific, and the board being so.

12,148. (*Sir J. P. Kay-Shuttleworth.*) Does not that presuppose a disposition, on the part of the central administration, to take every possible opportunity of promoting science, and so of availing itself of the aid of scientific men for that object?—If the central administration does not care to promote science, it will not call for aid to do so in any form.

12,149. But are we warranted in supposing that the Government, as a whole, or take the cabinet as a whole, has either sufficient scientific information and consequent earnestness in the pursuit of scientific objects, or sufficient scientific insight, to originate those investigations or observations?—I should say that, as now, the demand for the investigations would originate either in the scientific world or in the scientific institutions, not in the cabinet or with the ministry.

12,150. That remark would apply to those departments which are of a mixed scientific and practical character, such as the Army and Navy Departments, for instance; but would it apply to departments generally, or would it apply to the action of the Government as a whole?—To the departments. I think that the action of the Government, as a whole, would vary with every ministry.

12,151. Is it not, therefore, in a great State, the prosperity of which depends to a very great extent, indeed, first on a knowledge of scientific laws, and then on the application of them to the wants of the State and the community, desirable that the State should possess some means of scientific appreciation and insight?—I quite agree, but the question before us is, whether the State and the community are sufficiently advanced to appreciate or to entertain the idea of a great general council for science.

12,152. Supposing the education to have been very defective, first of the legislative deliberative body, that is Parliament, and then of the selected men who are the executive Government for the time being, and that, in consequence of the one-sided character of their education, they are deficient both in scientific knowledge and in scientific insight, is it not expedient to supply, by some artificial, and it may be temporary means, the want of the qualifications which would enable them to get those advantages for the State?—I think that a first step towards supplying this want might be the constituting such departmental boards as I suggest.

12,153. There is still an appeal from the Government itself to the opinion of the scientific world, which would condemn inefficient appointments, seeing that so much would depend upon the complete and pre-eminent efficiency of the appointments made to such a council?—I have no doubt that, as conscientious men, every minister would be anxious to secure the scientific advice of a council appointed to assist him; but I doubt the Government being advanced enough in the interest of science to advocate the appointment of a general council which would be armed with powers that enabled it practically to override the Government and almost complete its action in questions of scientific expenditure.

12,154. Does not your answer leave us in the comparatively hopeless condition of having no escape from the admitted inefficiency of the Government, so called, to direct scientific investigations or the application of scientific laws for the benefit of the community?—I do not think it does; I think that if you get in the small end of the wedge by appointing those scientific boards to aid in the administration of existing scientific institutions in which various departments of the Government are already interested, and which, I believe, they conscientiously wish to work well, you would then have the means of judging whether a great council, which would have greater scientific weight in the councils of the nation, was a desirable thing.

12,155. But seeing how much has been done by the various voluntary scientific associations of the country, and seeing that, in fact, the advancement of science is almost solely attributable to them, are you not of opinion that the condition of science, resulting from their operations, is such as to warrant the Government in soliciting the advice of the most eminent men belonging to those societies?—I must confess that it appears to me that there is extremely little done by the general public for the advancement of science. A great deal has been done by the liberality of a few individuals, but when you consider the starved condition, in a scientific point of view, of the museums, botanic gardens, and other scientific establishments in

J. D. Hooker, Esq., M.D., C.B., F.R.S.

19 June 1872.

such gigantic towns as Manchester, Leeds, Huddersfield, and Glasgow, whose wealth is the fruit of scientific research, I do not think that the people of this country can claim any very great credit for scientific liberality.

12,156. My question did not in any degree refer to the liberality of the general public, but rather to the scientific exertions of voluntarily formed associations, such as the Astronomical, the Chemical, the Zoological, and other associations, and my meaning was whether, seeing how much has been done by the associations of scientific men for the advancement of science, it does not become a question whether the Government would be acting rightly if it did not avail itself of the assistance of the most eminent scientific men?—I quite concede that the Government should avail itself of the assistance of scientific men, and this they might do in the form which I propose, though they might not feel called upon to create such a body as a general council of science. I mean to say that the Government might see its way to the smaller measure, but not to the larger.

12,157. Supposing that the proposal were not to form a council of science which should represent every particular branch, but rather a council which should represent the spirit of scientific investigation, and the knowledge which pre-eminent men would have of persons qualified to conduct scientific investigations, would not a smaller council of, say, six pre-eminent scientific men, recommend itself in a greater degree to your mind?—I have no question of the value of such a council, but I do not see my way to its appointment by a Government that wants aid so to enlighten itself to discern the spirit of scientific investigation.

12,158. (*Professor Stokes.*) Is the difficulty that you feel derived from supposing that the Government would not be willing to grant the salaries of the council?—It is not so much that, as that they would not see their way as to the practical working of such a council.

12,159. (*Chairman.*) That is to say, there is no public opinion in the country that would encourage them to have recourse to such a council?—I do not think there is; but that is another question, as to which, I confess, I do not give my opinion without great hesitation.

12,160. Each of those councils or boards of inspection that you recommend would be composed, would it not, mainly, or, perhaps, exclusively, of persons conversant with one particular branch of science?—Mainly of persons conversant with those special branches of science to the cultivation of which the institution is devoted, aided by some persons of general scientific culture or appreciation of science.

12,161. Would you propose that they should be called upon, as a matter of duty, to furnish annual reports?—Decidedly.

12,162. (*Professor Stokes.*) Do you think there is any danger that if there were boards formed in this manner for the individual sciences, each would urge on very strenuously its own science, and that the assemblage of propositions would be more than the Government could entertain, whereas, if there were a general consultative body the claims of the different sciences would be weighed against each other?—Each would do its duty, in its own line, in pointing out to its own branch of the Government what it thought right to be done. It would be better that in this each branch of the Government should act independently, rather than be influenced by the demands of the others. A great deal of outside influence might be brought to bear upon a single body in the event of a popular subject being mooted as deserving of a large subsidy, to the detriment of less popular but equally important subjects. Whereas, did each, acting on its own authority and according to its own judgment, give an independent opinion as to what was wanted for its own branch, the collected opinions of the boards would represent, with an approximation to exactness, the requirements of science for the time being.

12,163. Then in case there were more applications sent in than the Government could entertain, do you think that the Government would be a better body to make a judicious selection from amongst them than a general consultative body of scientific men?—I think that, in such a case as that, the Government should select from the various boards a body who would decide upon the distribution of such sum of money as the Government would consent to give.

12,164. Then you do contemplate, apparently, the formation of a general scientific council, only that it should be called together from time to time, or else that a certain number should be called together from time to time to form such a council?—Yes.

12,165. (*Chairman.*) Not necessarily always consisting of the same members?—Not necessarily always consisting of the same members.

12,166. (*Professor Stokes.*) But does it not seem to you that a small scientific council presided over by a minister, or some person acting in his stead, would come to understand, to a certain extent, the views of the Government as well as of scientific men, and would be better able to weigh those views against one another than a board whose attention was devoted to some special scientific object which they would press forward with all their power?—You are assuming the existence of a minister to whom Government would entrust this power. There is no such minister at present.

12,167. I do not make any supposition as to the formation of any new minister, but that there should be simply some Government authority in connection with the board and consulting with it?—Practically that is Government appointing a minister.

12,168. Not necessarily a new minister?—But a minister with new duties, which is practically the same thing. It would always be a question for the Government to consider, whether it would devolve this duty upon any existing minister or on a new minister, or on the Cabinet, or, as at the present, on the Chancellor of the Exchequer. Give the trusted council or boards, and then the money is the only question the minister can care to look to.

12,169. (*Dr. Sharpey.*) To whom would these boards of visitors whom you contemplate have to make reports?—Each to the department of the Government under which the scientific institution was administered.

12,170. For example, in the case of Kew, would they have to report to the First Commissioner of Works?—They would report to the First Commissioner of Works.

12,171. Professor Stokes was suggesting the possibility of there being a minister to whom all those matters could be reported from all the different departments; say, for example, a permanent under secretary of state who was sufficiently instructed in science and, at the same time, acquainted with administrative duties to receive and consider those reports. What would be your opinion of such a suggestion?—From the little I know of the details of the administration of the country, I should think that a permanent under secretary of state would have comparatively very little power, and that no one with anything short of a seat in the cabinet would have sufficient influence with the Chancellor of the Exchequer.

12,172. (*Chairman.*) Should you like yourself to see the establishment of a ministry of science?—I think that a minister of education is extremely wanted, and I think that the scientific institutions might be administered by him as minister of education and science. This is, however, a question, whether more is to be got by one minister's asking a lump sum for all science, or by several ministers, each interested in his own institution, catering for himself. I do not believe that what is called the stinginess of the Government in scientific matters arises so much from a wish to withhold money, as from the want of confidence which the Government has in the way their grants may be administered. But as regards its constituting a general council to inspire itself with this confidence,

J. D. Hooker, Esq., M.D., C.B., F.R.S.

19 June 1872.

the practical difficulty, as it appears to me, always will be this, that the Government will exceedingly dislike devolving upon any other body, the authority and responsibility that should attach to itself. Nor would it like the pressure that a council would exert upon it.

12,173. (*Dr. Sharpey.*) That would be assuming that the council would interfere with the administrative duties of the Government?—Yes, and which it might always feel itself called upon to do in respect of the scientific duties of the Government.

12,174. But only if it were called upon; it would not do it spontaneously?—It would be its duty to do it spontaneously if it thought that the Government were wrong, and that they could set it right, or else I do not see much value in the council at all.

12,175. (*Professor Stokes.*) In the case of a legal difficulty, do not the Government consult the law officers of the Crown?—I assume that they do, but that is a question which I am not prepared to go into.

12,176. Might they not, in a similar manner, in the case of a scientific difficulty, consult a council of science, it being left free to the Government on their own responsibility to accept or reject their advice?—If you give the council the position and powers of the law officers of the Crown, then, practically, the Government would be, after consultation with it, no more free than it is now free after consulting its law officers. Parliament would rest upon the opinion of the council; it might resist the requirements of the minister, but not the requirements of the council. I may be wrong, but I do not see how the Government could approve of the creation of a board with the influence of its law officers, which would have so direct an object in taking responsibility off its own shoulders, and authority out of its hands. On the other hand, there is a good deal to be said in favour of the minister feeling the responsibility of the institution which he has to administer. Again, the Government seeking a scientific opinion is not quite a parallel case to that of its seeking legal advice. More or less, every minister and every person high in office has, himself, more or less knowledge of the law. He does not go to the law officers in all but complete ignorance, as he would to the scientific council.

12,177. (*Sir J. P. Kay-Shuttleworth.*) Do not your apprehensions presuppose one of two things, either that it has been proposed to create a council which should fulfil the function of a scientific dictation, or that the council would so command the confidence of Parliament as to become supreme over the Government in all matters of science?—I think that if the council commands the confidence of the people, it would become a scientific dictator, from its being, as you yourself pointed out, a sort of supplement to the Government, wiser than itself.

12,178. (*Dr. Sharpey.*) I still scarcely see how your arrangement would provide for various questions in the relation of the Government to science which from time to time occur. Take the case of the question of establishing a professorship of civil engineering in Edinburgh, whom could the Government consult? or the division of the natural history chair of Edinburgh into a chair of zoology and a chair of geology; those are all questions upon which, at present, some minister or other, say at the Home Office or at the Treasury, consults private persons, and nobody knows who gives him advice, and, therefore, the public are not informed upon it; would not it be much better if there were some responsible body, whose acts were made public, and who might report to the Government on questions of that kind which were submitted to them?—I do not see why the Government, in such cases, should not choose from the visitors to the East India Engineering College one man, from the Royal Artillery another man, from the Greenwich visitors a third man, and so on. I think that when you consider the nature of the duties which the existing officers in the Government institutions have to perform, you would have no difficulty in selecting half-a-dozen good men, able and willing to select a professor of engineering or geology, or of any other branch of knowledge.

12,179. Do you mean as occasion arose?—Yes, as occasion arose. By such means you would get rid of the great difficulty of having a standing supreme council armed with authority, and which would possibly become imbued with fixed ideas, prejudices, and all the evils of a permanent legislature.

12,180. The Government might still override the opinion of the council; they would merely consult the council?—The Government might well be induced, by external pressure, to override the decisions of the standing council; but it would not summon its special council if it were not prepared to accept its views.

12,181. (*Professor Smith.*) You spoke of the limitation which you wished to impose upon the board of visitors; to what did you particularly allude?—That each should have the power of annually inspecting the institution to which it is appointed, and should read the report of the director of the institution, adding any recommendations of its own, such recommendations having previously been submitted to the director. But it should have no power of directly interfering with the director's duties, authority, or responsibility.

12,182. You mean the report being shown to the director, but not submitted for his sanction?—The recommendations being shown to him, so that he might not afterwards say, if I had seen this before it was sent in I could have pointed out to the Government how inexpedient this proposal was. It would be a body, in fact, to which the Government or the director could apply in a case of difficulty.

12,183. How do you think that such a board of visitors ought to be constituted?—I suppose that the members would be appointed by the Prime Minister, in consultation with the department.

12,184. You think that it should be chiefly a scientific body?—Yes; but it would be well to strengthen each board by adding to it some member or members of Parliament with a knowledge or appreciation of science. I think that the Government could be induced to listen to such a scheme as this, which would lighten the responsibility of the ministers, without diminishing its authority, and which would inspire the public with confidence.

12,185. (*Chairman.*) Are you prepared to give evidence upon any other matters? Do you think that the action of the Government should be called into more systematic operation with a view to the advancement of science?—Decidedly.

12,186. Can you point out the directions in which you think the Government should act for this object?—I think that one very important one is what I gave evidence upon before, viz. the organisation of the new Natural History Museum, by placing it under a director responsible to a minister of the Crown, and making it both more useful to science and more distinctively instructive to visitors. I think that a great deal more might be done both there and at Kew with regard to various departments of botany. And there are many other ways (although I am not prepared to go into them) in which aid might be given to science.

12,187. Does it appear to you that any additional institutions for the advancement of science are urgently needed?—I have not considered that point. I think that many existing institutions admit of much further development at no extravagant outlay.

12,188. And the institution of such boards of visitors as you recommend would facilitate the further development of such institutions?—I think so. Such boards might at once point out, each in its own department, where great good might be done under existing arrangements, at comparatively very little increase of expenditure.

12,189. Are there any other points upon which you would like to give the Commission your views with regard to this question?—I do not remember any other point.

12,190. (*Professor Smith.*) With regard to the reference which you made to physiological botany at

J. D. Hooker, Esq., M.D., F.R.S.

19 June 1872.

Kew, do you contemplate the idea of establishing a new department of inquiry at Kew?—No, rather giving grants for special inquiries to be made.

12,191. Do you mean experimental inquiry?—Yes.

12,192. Such inquiries are carried on there from time to time, are they not?—Very little indeed. Such questions as that of the influence of coloured media upon vegetation, and many questions relating to the chemistry of botany, have never been pursued at Kew. I have repeatedly urged young experimenters to commence, offering them facilities, but the difficulty with them has always been to give the time, and get funds to support themselves.

12,193. Have you any assistant at Kew under you whose duties consist in inquiries of that kind?—None.

12,194. And you think that there ought to be?—I am not prepared to say whether the aid should be given in the shape of an assistant to myself. The great thing would be to get the money to induce an experimenter to commence such observations.

The witness withdrew.

Adjourned to Friday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 21st June 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

R. Grant, Esq., LL.D., F.R.S.

21 June 1872.

ROBERT GRANT, Esq., LL.D., F.R.S., examined.

12,195. (*Chairman.*) I believe you are Professor of Astronomy in the University of Glasgow and also director of the observatory?—I am. I may state, before commencing my evidence, that upon leaving Glasgow, from information I received, I was under the impression that the evidence that I should be expected to give would relate purely to astronomical matters, and with special reference to the observatory of the University of which I am director; but since I have come to town I have been informed that the evidence expected to be given would be of a more general kind. This may account for my evidence not being so full as otherwise it might be.

12,196. Have any schemes suggested themselves to your mind, the adoption of which, in your opinion, would tend to promote the advancement of science in this country?—It appears to me that any comprehensive scheme in the present state of the country would be very undesirable. There does not exist sufficient sympathy in the country in favour of either scientific instruction or the advancement of science, and, therefore, any great or comprehensive scheme for that purpose would, in my opinion, result in absolute failure. The country is not yet sufficiently prepared for any such scheme. The public mind must be educated to appreciate the results of scientific research. I do not think, therefore, that, in the present state of matters, any comprehensive scheme would be desirable.

12,197. Do you think that arguments on this subject might be drawn from what is done in foreign countries?—It is a very common practice to refer to Germany, but there exists a wide distinction between England and Germany in regard to the social condition of their respective peoples, and this circumstance, in my opinion, must be carefully taken into consideration in any comparative estimate of the extent to which science is cultivated in the two countries. In this country we are, above all, a political people. The education of our country gentlemen has been framed for that purpose, first at the public school and then at the University, and this education has been less favourable to science than to literary culture. Nor are the active out-door habits of English gentlemen, in my opinion, favourable to sympathy with scientific researches. In another respect, also, we labour under a serious disadvantage in as far as the cultivation of science is concerned, although the circumstance itself from which this disadvantage springs constitutes one of the sources of the material greatness of the country. We are pre-eminently a commercial nation. Every year a large proportion of the youthful talent and energy of the country is drafted into the innumerable channels of a commercial career. The consequence of this state of matters is, that science is left to struggle as it best can without sympathy or support from the great mass of the better-educated classes of the community.

12,198. Do you think that the conditions in Germany are of a different character?—In Germany the public mind is not so much absorbed in political discussions as in this country, nor does there exist the same temptation to embark in a commercial career as with us. The result is, a life of comparative tranquillity which is especially favourable to the cultivation of science. Again, ever since the Reformation the subject of education has received a large amount of public attention in Germany, and science in recent years has become closely connected with the educational institutions of the country. The various grades of these institutions have received a better organization and have been established upon a more comprehensive plan than the corresponding institutions in this country. These various circumstances, in my opinion, account for the more satisfactory condition of the cultivation of science in Germany than in the British Isles.

12,199. Can you suggest any measure which you think it would be practicable to adopt in order to further the advancement of science?—By connecting the cultivation of science closely with the educational institutions of the country; I may refer as an instance of such institutions to Owens College, Manchester. This is an institution which provides for giving instruction in various important branches of science. If properly supported it might also be made available for purposes of original research.

12,200. Do I understand that you would recommend that Government assistance should be afforded to develope Owens College?—I am of opinion that Government assistance should be given in aid of such an object. Owens College I regard as a type of educational institutions of the higher kind which are rising up in different parts of the country, chiefly in the industrial towns, where the practical advantages of science offer themselves more readily than in other communities. If those institutions received due support from the Government, their prosperity and usefulness would be greatly enhanced, and they would thus prepare the way for the gradual extension of such institutions over the whole country. This result, in my opinion, would utimately conduce, in an eminent degree, to the advancement of science.

12,201. Have you any other recommendations to

R. Grant, Esq., LL.D., F.R.S.

21 June 1872.

make?—I consider it to be of the highest importance that between the primary schools, on the one hand, and the Universities, on the other, there should be established a system of secondary schools in which a course of scientific instruction would be given. It appears to me that the educational institutions of different grades should be connected together, so that a youth of talent, however poor, might be enabled, by means of endowed facilities, to pass from the primary schools to the highest Universities of the land. By establishing secondary schools in the provincial towns, much good would be effected in this way. I may refer, in connexion with this remark, to the second and third-rate towns of Lancashire, such as Preston, Warrington, and Rochdale. It appears to me to be perfectly practicable to establish in those towns secondary schools at which a course of instruction would be given in mathematics pure and applied, general physics, chemistry, mineralogy, and geology, all of which studies would have, in general, a direct bearing on the future career of the youth attending such schools. I do not think that such an institution as Owens College, Manchester, will flourish unless it is nourished by schools of this kind.

12,202. Are you sufficiently acquainted with the state of secondary education in this country to be able to say whether there are any schools at present in existence which correspond to your idea of what secondary schools should be?—I am not aware of any secondary schools in which sufficient prominence is given to scientific culture.

12,203. You are aware that in the schemes now being gradually introduced by the Endowed Schools' Commissioners a certain amount of instruction in science is usually provided for?—Yes; but it appears to me that there is not sufficient prominence given to it.

12,204. Do you think that secondary schools should be established with Government assistance?—Yes, with Government assistance.

12,205. But not established solely by the Government?—By no means.

12,206. But that the Government should give aid when the inhabitants of the district were willing to furnish a certain amount of funds?—Precisely so.

12,207. In what shape do you think it would be best that Government assistance should be afforded to the higher educational institutions?—In the first place, by endowing the professors with salaries to maintain them properly, and then, by providing all such institutions with laboratories, which would enable the professor not merely to illustrate his lectures, but also to carry on original researches, and not merely so himself, but also the more promising students, who might in this way be led to engage in the cultivation of science.

12,208. Do these last remarks apply in any degree to the Universities of Scotland?—I can speak upon this point only in so far as the University of Glasgow is concerned, the physical laboratory of which, as far as I learn, is in a very efficient state.

12,209. Is it adequate for the purpose?—Yes, as far as I learn.

12,210. In what condition is secondary education in Scotland?—It is in a very imperfect state indeed. The schools which profess to give an education superior to that obtained at the ordinary parish schools are very defective in so far as scientific instruction is concerned, and until they are placed upon a better footing the Universities must suffer from the non-existence of means for the proper training of students previous to matriculation.

12,211. (*Dr. Sharpey.*) Do you mean that the Universities have now to take up a duty which ought rightly to fall to the secondary schools?—Yes, quite so.

12,212. (*Chairman.*) There is, according to your views, as great a necessity for establishing secondary schools in Scotland as in England?—Quite as great.

12,213. Do you think it would be proper for the Government to encourage private persons engaged in scientific pursuits?—I consider that no scheme for the advancement of science in this country would be complete which did not include a liberal provision in aid of private persons engaged in scientific researches. While it may be naturally presumed, as a general rule, that science will be most effectually promoted by persons officially connected with scientific pursuits, it is certain, on the other hand, that there are persons constantly springing up outside of scientific establishments who, by their researches, have contributed, in a marked degree, to the progress of science. What has been already effected in this direction has been most beneficial in aiding such persons, but it can hardly be doubted that the results accruing to science from private efforts would be greatly extended if a more liberal provision in their behalf were made by the nation.

12,214. What are you referring to now, as having already been done in that direction?—I refer to the Government grant of which the Royal Society has the management. We have seen so much good effected by it in the way of extending science, that in my opinion it would be very desirable if the grant were enlarged. Perhaps, also, it would be expedient that wider publicity were given to the fact of its being generally available te persons engaged in scientific investigations.

12,215. Are you acquainted with any instances in which special grants have been made by the Government for special purposes, exclusive of this Government grant administered by the Royal Society?—I am not aware of any. I am solely referring to the Government grant of the Royal Society.

12,216. You would like to see that grant considerably increased?—Yes.

12,217. Is its existence generally known in Scotland?—I should say that it is not so generally known in England or Scotland as, perhaps, would be desirable. This appears to me to be the only objection that I could offer to it; in other respects it has been admirably dispensed, and has been of great value; but I think that it would be better to give wider publicity to the fact of its being available to all the country.

12,218. (*Dr. Sharpey.*) Do you think that your remark applies to scientific men?—Yes, to scientific men.

12,219. That even they are not quite sufficiently aware of the existence of the grant?—No, they are not.

12,220. What would you suggest as the best mode of giving greater publicity to it?—Occasionally advertising it.

12,221. (*Sir J. Lubbock.*) That would be especially the case if the amount were increased, no doubt?—Yes, it would be more especially called for.

12,222. (*Chairman.*) Would you wish to see much larger grants made for special purposes than are given at present; I believe that the personal expenses of those engaged in these pursuits are not taken into consideration?—This is a matter upon which it is more difficult to pronounce an opinion than in the case of an educational institution the requirements of which have the advantage of being definite, and, therefore, readily ascertainable. It appears to me that it rests more with the experience of those who may have the dispensing of the grant, to assign from time to time the limit within which it may be proper to include it.

12,223. (*Dr. Sharpey.*) Do you think that there would be any considerable advantage in assigning a grant of a certain amount to the Royal Society of Edinburgh for distribution by them in Scotland, in the same way as the existing grant is distributed by the Royal Society of London?—It might have the effect of giving greater publicity to the grant; but the same means might be served by one institution. I do not see the necessity of having two.

12,224. You are not aware of any application from Scotland having been declined?—Certainly not; nor from any other place. I think it would be better

R. Grant, Esq., LL.D., F.R.S.

21 June 1872.

(and I have heard other persons make the remark) if it were made more public.

12,225. And that it would be one means of making it more extensively known, if its distribution were partly entrusted to a scientific body in Scotland?—I have not heard that stated, and it has never occurred to myself. The British Association do much good in that way in giving local publicity to the fact that their funds are to some extent available for the use of persons engaged in scientific researches; and the fund of the Royal Society, if it were well advertised, I think, would be equally taken advantage of in local communities.

12,226. (*Chairman.*) What are your views as to the relations which ought to exist between the Government and the scientific societies?—In the present state of matters, they are, in my opinion, most unsatisfactory. The Chancellor of the Exchequer looks only to making out a good account with the public; and the consequence is, that when any scientific matters come before him he studiously ignores them; he has no sympathy with them, and he seems quite safe in flinging any such considerations aside. But if there were a minister appointed for the purpose, for conferring with the scientific bodies and coming to some general conclusion as regards the scientific wants of the country, and if a report on the subject were presented annually to the Government, the Chancellor of the Exchequer or any official of the Treasury would not feel justified in rejecting it summarily. Therefore, I think it is of the utmost importance that there should be a Government official acting in concert with representatives from some of the principal scientific and educational bodies of the country, who would consider all demands for money laid before them in the course of the year and report to the Government accordingly.

12,227. Are those recommendations made with a view of enabling the scientific societies to do their work more efficiently, or with a view to the promotion of national objects and national advantages?—It is mainly national advantages that I am considering. The operations of such societies, being scientific, are essentially national rather than local.

12,228. I do not clearly understand whether you think that in all cases the scientific societies should receive financial support from the Government?—In speaking of scientific societies, I may state that it appears to me desirable that they should all receive a certain amount of national support. The public, as far as I learn, have never offered any opposition to the assigning of grants of money in favour of educational or scientific objects. It is from the Government alone that all such opposition comes.

12,229. (*Sir J. Lubbock.*) What do you think would be the advantage to the societies of having what you call the prestige of the Government; I do not quite understand your meaning? I refer to the moral support which such societies would derive from the fact of being recognized by the nation, and partially aided in their efforts to cultivate science. I do not consider that the Government should recognize and uphold them to the same extent as it does some of the higher scientific societies; but it appears to me that a certain measure of public support would be accorded with very beneficial results to the various minor scientific societies which have been established throughout the country, and are usefully engaged in cultivating the different branches of science. It is to be borne in mind that the persons of which such societies are composed have been drawn together by a common sympathy with scientific pursuits, and that, generally speaking, they are not wealthy. The support of the Government would, however, in my opinion, have the effect of drawing the attention of the wealthier members of the community in each case to the labours of the society, and inducing them to co-operate in advancing its interests.

12,230. (*Dr. Sharpey.*) What are the chief difficulties that they have to contend with?—I take the case of Glasgow. There is a scientific society in that city, which was established about the beginning of this century. It possesses a revenue of about 600*l.* a year, and its published Transactions contain numerous papers on scientific subjects. It is, however, unprovided with a place of meeting of its own, and although there is every probability of its receiving support in aid of a building for that purpose from some of the wealthier merchants of the city, still something is wanted to give a stimulus to the agitation in favour of the movement. If the Government, in such a case, were to come forward and say, we will give so much provided you raise so much for yourselves, I am certain that the money would be raised, and a handsome edifice would be built in a short time.

12,231. That would be by combining the aid of the Government with local contributions?—Yes.

12,232. Because, if the Government were to undertake the support of those societies, do not you think it would rather tend to cool local efforts?—Yes; I do not mean that it should go beyond aiding them in obtaining a building for transacting the business of the society, and occasionally, perhaps, extending to them a little pecuniary assistance.

12,233. Has the Glasgow Society, or any society which you are acquainted with, of the kind that you are now referring to, a difficulty in publishing useful transactions?—No; the funds of the society suffice for that, and they publish regularly many useful papers on different subjects.

12,234. (*Sir J. Lubbock.*) The prestige that you refer to would be, I believe, in your opinion, an indirect result of imperial assistance?—Yes, and the prospect of being supported by the Government on any future occasion.

12,235. You think that local subscriptions would come more regularly if there were an assurance that they would lead to Government support?—Yes.

12,236. Are you of opinion that materials exist in this country for the establishment of many more scientific societies in the provinces than exist at present?—I think that if the Government were to support such societies they would increase in number.

12,237. Would you attach any conditions to any support afforded by the Government towards scientific professorships?—I should certainly enjoin that every professor should deliver a course of lectures upon the subject which he teaches, whether it be short or long. It may be short or long according to circumstances; but, in any case, it appears to me highly desirable that he should deliver annually a course of lectures.

12,238. Do you mean in addition to his duties in his special institution, and would you have the lectures open to the public?—In some of those professorships where the occupants are engaged a good deal in experimental or observational work, it may be considered laborious to deliver also a course of lectures. I understand that there have been objections to the effect, that it would be impossible to combine the two together; but it appears to me that it would be very undesirable to drop lecturing. I do not know that the Royal Institution would have been so successful in its career for the advancement of science if there had not been a course of lectures combined with the laboratory work. I think it is in the highest degree desirable that the professor of any branch of science should deliver annually a course of public lectures. It is an encouragement to him to be thus brought periodically face to face with the public. He has not the same stimulus to exertion in the laboratory when he is working in quiet retirement.

12,239. (*Dr. Sharpey.*) That would be a collateral duty of the professor?—Yes.

12,240. His main duty being the teaching of science to the students, and especially also the prosecution of original research?—Yes.

12,241. That is to say, I presume, you would not suggest the institution of mere lectureships with nothing else connected with them, as, for example, at the Gresham College here in London, where the lectures are open to the public, but who, I suppose, take little interest in them?—Quite so; I have reason to

R. Grant, Esq., LL.D., F.R.S.

21 June 1872.

know this, because I lived at one time in the city. I know that the lectures are delivered, but they are never attended; scarcely half a dozen go to listen to them.

12,242. Your proposal is quite a different thing from that?—Yes, certainly.

12,243. (*Chairman.*) Would not there be a fear that the professor's time would be so much taken up in lecturing and preparing for lectures that he would not have sufficient time to give to original research?—There exists here a difficulty which must occur to any person. In the Scottish universities an attempt has been made to meet it by appointing, in some instances, an assistant professor. But even that is not sufficient; the labour is too great, even for two persons. I do not see how the defect is to be remedied, except by giving the professor sufficient assistance for laboratory work as well as for teaching purposes.

12,244. You think it desirable that the professors should be engaged in original research?—Yes. It appears to me that that is the only way in which we can expect, as a general rule, that science is to be advanced. There is more probability of science emerging from the laboratory in that way than from the chance researches of private persons.

12,245. What are your views as to the appointment of a Board, whose duty it would be to consider and report to the Government respecting such sums of money as it would be desirable to provide for scientific purposes?—To a Board of this kind it would be the duty of every person concerned to send a report of the state of his operations during the year; and if there should be any further sums of money required beyond the annual outlay, it would be the duty of every such person to submit the same to the consideration of the Board, to send reports to such Board.

12,246. You consider that such a Board is needed? —I think it is indispensable.

12,247. How would you constitute a Board of that kind?—It appears to me desirable that it should be composed partly of members representing the higher educational institutions of the country, and partly of members representing the various scientific societies, and that there should be a Government official acting in concert with them.

12,248. Would you contemplate the Board being somewhat numerous?—I do not think it would be either necessary or desirable that it should be numerous.

12,249. If all the more important educational institutions and all the more important scientific societies were also represented, it would be rather difficult to keep the number down, would it not?—What I mean is, that there might be a small number of permanent officials appointed, and that it would be the duty of the various persons concerned to report to them; but whether they should be appointed by the Universities and scientific societies, or whether they should be chosen from the members of those corporate bodies by the Government, is a point upon which I am not prepared to offer an opinion.

12,250. Do you propose that this Board should undertake the duties now undertaken by the council of the Royal Society as well as others?—I am not prepared to state to what extent it would be desirable to combine the two together, or to keep them separate.

12,251. Do you think it would be necessary to give salaries to members of the Board?—Yes, I think so, because they would have a great deal to do.

12,252. Do you think that their work would be of a tolerably constant nature?—Yes; I think so.

12,253. (*Sir J. Lubbock.*) At present there are practically several Boards, each one with special comparatively limited functions, such, for instance, as the Board of Visitors at Greenwich, the Board of Trustees of the British Museum, although unfortunately there are very few of them scientific, and then, again, the Government grant that is under the control of the Council of the Royal Society, or, rather, the Committee appointed by the Council; and the Meteorological Department is, again, under a special Meteorological Committee. Do you think it would be better to have one general board to which all scientific questions would be committed, rather than to continue the system of having special boards for the different departments of science?—In the case of the Greenwich Observatory, the Board has worked so well that I do not think it would be desirable to interfere with its functions.

12,254. Then you would exclude from the functions of such a board any control over the Greenwich Observatory?—Yes, certainly.

12,255. Do you think that the arrangement with regard to meteorology could be improved?—I do not see, in the mean time, that any improvement could be effected in the mode of working.

12,256. Apart from the question of whether the present constitution of the Board of Trustees of the British Museum is a good one, do you not think it is desirable that the management of the British Museum should be under a special committee or board?—It is a question that I have not considered, but I have always been of opinion that this scheme, which is now being considered, would have no reference to those institutions which were under the direct control of the Government, such as any of the Government establishments at Woolwich, or the Ordnance Survey at Southampton, or any of those under the Admiralty.

12,257. Or all questions relating to the construction of ships, to the nautical almanac, or all scientific questions connected with the management of the Admiralty?—Yes; unless the Government called upon the Board for their assistance, I think it would be unwise to interfere with what the Government have exclusively assumed to themselves.

12,258. Then you would practically limit the functions of the board, would you not, to the expenditure of the 1,000*l.* which the Government now allots to science, or whatever larger sum might be allotted?—Yes, to the sums that might be required for such institutions as I have mentioned, namely, all secondary schools which are formed mainly with a view to scientific instruction, and do not come within the scope of the Ministry of Education, the higher educational institutions of the country, the various scientific societies, and private persons engaged in scientific research.

12,259. Then you would have this grant submitted for consideration to this scientific council?—Yes.

12,260. I understand you, then, to say that you consider that the administration of the Government grant by the Council of the Royal Society has hitherto been quite satisfactory?—Yes; I have never heard any adverse opinion expressed as to that.

12,261. (*Professor Stokes.*) You advocated, I think, the principle that the Government should support, more or less, educational establishments, so far as regards the teaching of science?—Yes.

12,262. You do not contemplate that such establishments should be supported as regards the teaching of other useful branches of knowledge, such, for example, as modern languages?—Yes; my view is that those secondary schools should embrace instruction in the modern languages, and even in the ancient languages if desired; but that in all such secondary schools there should be also due prominence given to instruction in science, which is not given in our secondary schools which exist at present, by which I mean the endowed schools throughout the country.

12,263. My question was, rather, whether the Government should give aid towards the study of modern languages, and generally all useful branches of learning, concurrently with aid to science?—I am not prepared to speak upon that; although, at the same time, I may state that to make the seminary an efficient one it would be desirable that it should embrace the teaching of modern languages.

12,264. By what argument would you justify to the country the making of this distinction between science, on the one hand, and other branches of learning, such as modern languages, on the other, so that the State should give aid towards the prosecution of the one,

R. Grant, Esq., LL.D., F.R.S.

21 June 1872.

but that the prosecution of the other should be left to private resources?—I did not state exactly that the Government should refuse aid, but I did not contemplate the giving of aid in my reference to what I said about scientific instruction. I do not see my way clearly, I must say, as to the Government giving aid for the teaching of modern languages.

12,265. (*Dr. Sharpey.*) Perhaps you may think that those are branches sufficiently well provided for already?—Yes, I think so.

12,266. (*Chairman.*) Do you think that further support is required for the promotion of astronomical science?—I shall most appropriately answer this question by making a brief statement respecting the observatory of which I have the superintendence. The professorship of astronomy in the University of Glasgow was founded by the Crown in the year 1760. In the Commission for his appointment, the occupant of this chair is styled Professor of Astronomy, and Observer in the University of Glasgow. The two offices here indicated are therefore co-ordinate offices, each holding directly from the Crown. A salary of 50*l.* a year was originally attached to this professorship by the Crown, which reserves to itself the right of nominating the occupant. This was supplemented by the University to the extent of 220*l.* The entire emoluments of the office consist, therefore, of a salary of 270*l.* a year, with a dwelling house. There was no provision made for an assistant observer, and so long as the observations were carried on merely occasionally, as was formerly the practice at all University observatories, an assistant was not required. In the year 1843, however, the University contracted with the Government an obligation, which, henceforward, rendered an assistant indispensable. In consideration of a grant of 2,000*l.*, obtained from the public funds in aid of the present observatory buildings, the University engaged with the Government to supply the shipping of the Clyde with correct time. This obligation entailed a course of continuous star observations, which again involved the necessity of an assistant. No provision, however, was made for an assistant until towards the close of 1865, when the University finally appropriated 100*l.* a year for that purpose. The establishment is furnished with instruments of first-rate excellence. The transit circle was, until quite recently, the most powerful instrument of the kind in the British Isles outside of the Greenwich Observatory. For extra-meridional observations, the institution possesses a magnificent equatorially-mounted refractor, the acquisition of which is due to the munificence of a few gentlemen of Glasgow. Many astronomical observations have been made with both these instruments. With the transit circle a system of star observations has been regularly prosecuted since the year 1860. The number of such observations amounts to several thousands, but the operations connected with their reduction, always the most onerous part of the work of an astronomical establishment, are very imperfectly advanced in consequence of the want of any provision for computation. I may state that under the circumstances, such an extent of astronomical work could not have been effected without a considerable outlay on the part of the director for assistance in observing and computing. During the first six years, subsequently to my appointment in 1859, the average annual expenditure for assistance has amounted to 100*l.* It has since continued to be at least 70*l.* I may state that there is connected with the observatory a system of meteorological observations, supported by the Board of Trade, and placed under the superintendence of a committee of the Royal Society. This part of the work of the establishment, being self-supporting, is not included in the remarks which I have just made as regards inadequate endowment.

12,267. I think you said that some Glasgow merchants had provided funds for certain purposes; do you think that they would be disposed to do more in that direction if they were met by a certain amount of encouragement by Government assistance?—I think that if the Government were to assume the initiative in the matter, they would receive the co-operation of the wealthier inhabitants of Glasgow, who have always shown great liberality in contributing towards any public object as soon as proper measures have been taken to impress its importance upon them.

12,268. Is this professorship endowed more inadequately than the generality of professorships at Glasgow?—Yes; there are a few of the other professorships similarly circumstanced, but in general the endowments are on a better footing.

12,269. Are the fees that the professor receives smaller in amount than in other professorships?—Altogether they are insignificant.

12,270. In some cases, are not considerable sums received from fees?—Yes, considerable sums are received in some cases.

12,271. (*Professor Stokes.*) Do you think it desirable that the formation of a star catalogue should be undertaken by several observatories working independently, each making a catalogue of its own, or would it not be better that there should be a central observatory engaged in that work, and that the work should be left to the principal observatory?—No doubt there are many important advantages connected with such unity of action. At the same time I do not think it would be desirable that star-places generally, upon which the whole science of astronomy may be said to rest, should be dependent for their trustworthiness upon the operations executed at any one observatory. But independently of this circumstance, the work is of too great magnitude for such a scheme to be practicable. I may explain this remark by referring to the case of cometary observations. A comet is, generally speaking, visible only for a few hours in the western horizon after sunset, or a few hours in the eastern horizon before sunrise. The determination of its place in the heavens with a meridian instrument being thus impracticable, recourse is necessarily had to an equatorially mounted instrument for effecting the same object. But an instrument of the latter kind is incapable of assigning the absolute place of a celestial object with the precision required by the existing state of astronomical science. The astronomer accordingly determines the place of the comet, indirectly, by measuring with a micrometer its position relatively to some star which appears in the field of view of the telescope, or is removed only a small distance from it. In the excellent equatorially-mounted refractors with which public observatories are now generally furnished, a star of the ninth magnitude is a good object of comparison. Stars of this class are sufficiently numerous, that, in whatever part of the heavens a comet may appear, one of them is usually found sufficiently near the comet to be suitable for the process of differential observation to which I have referred. The determination of the places of all the stars in the heavens down to the ninth magnitude inclusive, becomes thus an object of fundamental importance in astronomical science. But the entire number of such stars in the northern hemisphere cannot be less than 150,000. To determine the places of so great a number of stars is obviously beyond the resources of any single observatory.

12,272. Do you think there is work enough for a number of observatories in the formation of those star catalogues, and that they should work in some manner in concert with one another, so as to avoid doing the work in duplicate?—Yes, certainly; but hitherto astronomers, like all other men of science, have been working under difficulties; and each man desires to do what he possibly can of the best kind. There has been no such thing as a comprehensive scheme and no common understanding.

12,273. (*Sir J. P. Kay-Shuttleworth.*) For the purpose of arriving at such common understanding, might it not be desirable that there should be some central body with whom the several observatories could communicate, and who, by friendly correspondence with them, might apportion the different regions

R. Grant, Esq., LL.D., F.R.S.

21 June 1872.

of work to the several observatories?—Yes; I quite agree with that.

12,274. That would come to be the function of any central scientific body with which the Government might be in contact as a council of science?—Precisely so.

12,275. (*Chairman.*) It would be scarcely possible, I suppose, to adopt any compulsory regulations of that kind?—Yes, quite impracticable.

12,276. It must be left to the discretion of each?—Yes. In Germany they have recently adopted a scheme of that kind, and it is now in course of operation, where the heavens have been parcelled out in that way, and they have all agreed upon each taking a portion; indeed, at Cambridge, Professor Adams has taken a portion of the work.

12,277. To a certain degree, it is done now as a matter of understanding?—Yes, as a matter of understanding on the Continent.

12,278. And to some extent also in this country?—Yes; in this country Professor Adams, I think, is the only one that is associated with that scheme. The recent fitting up of a powerful transit circle at the Cambridge Observatory would naturally suggest its desirability.

12,279. What are your views as to the importance of establishing an observatory for the cultivation of astronomical physics?—I think it is highly desirable that proper attention should be given to that subject, and that the Government should support its cultivation; but, as to the erection of an observatory, it may, perhaps, be considered to be attended with difficulties. The subject has hardly yet received the consistency, form, and substance of a science. In the case of all the observatories which have been established, the work is clear and well defined. There is nothing indefinite either in the work or in the building of the establishment. A clear view is obtained from the beginning to the end of the whole of the operations; but, in the present state of astronomical physics, I think there exists a difficulty, arising from the circumstance that the subject is hardly yet sufficiently advanced as a branch of science to justify the erection of an observatory, and its endowment with funds for the prosecution of a continuous course of observation and research. I think that while the idea of establishing such an observatory is entitled to the most careful consideration in the interest of science, its practical realization would, under existing circumstances, be somewhat premature; and that, in the meantime, the better plan would be to aid private research until the subject was a little more advanced, when clearer views would be obtained as to what exactly should be done.

12,280. Should you like to see private research encouraged in that direction by Government assistance?—I am of opinion that it would be highly creditable on the part of the Government to give such encouragement to private persons.

12,281. (*Professor Stokes.*) Supposing that the subject of astronomical physics were taken up by a national institution, would you be in favour of having a separate observatory for that special purpose or of engrafting it upon the work of the national observatory?—There are advantages and disadvantages in engrafting it upon any existing observatory. In the first place, there would be the advantage of having already a complete administrative machinery existing for the purpose, and then there would be also the advantage of harmonious connexion with the other branches of astronomy. But, on the other hand, there is one disadvantage which has struck me, which, perhaps, it might be difficult to get over. This opinion is founded on the presumption that the publication of the entire details of the observations would be impracticable. I have been led to infer so by the circumstance that the Kew observations of the solar spots have, heretofore, as far as I know, been communicated to the public only in the shape of a series of papers printed in the volumes of the Royal Society, under the designation of "Researches on the solar spots." It would be a very unsatisfactory state of things if scientific persons did not, under such circumstances, obtain ready access to an inspection of the original records. I am not quite sure if the necessarily rigorous arrangements of the national observatory would be consistent with such an intrusion on the part of even the scientific public. If, however, the reproduction of the original observations in a form for publication is quite practicable, the disadvantage to which I here refer falls to the ground.

12,282. Do you think that there is any serious difficulty in the way of a person who was engaged in some special research getting the necessary information that he required from the National Observatory?—I do not think that, under existing circumstances, any such difficulty exists. As far as regards the current observations, the details are fully published in the volumes which emanate annually from the observatory, and, consequently, there exists no necessity for the inspection of the original records. But if a scientific person wishes for information on some special point connected with the earlier observations or instruments of the establishment, the Astronomer Royal grants every facility for obtaining such information.

12,283. Do you think that, in a new subject like astronomical physics, it is desirable that the director of the establishment should be free to devote the principal part of his attention to its prosecution, or could it be worked through an assistant?—I think it is not sufficiently advanced to be worked by an assistant, unless he were an astronomer specially qualified for the purpose, and entrusted with a more than ordinary amount of responsibility.

12,284. (*Dr. Sharpey.*) Apart altogether from the question of the salary of the professor of astronomy or director of the observatory at Glasgow, have you formed any estimate of what additional funds would be required in order to put the establishment on a perfectly satisfactory footing?—I have not formed any such estimate, but I consider that, for the proper working of the astronomical part of the establishment, an assistant observer and a computer, or in other words, a senior and junior assistant are indispensable. There would be also a certain sum required annually for the printing of the observations. I feel pretty confident that if the Government were to make the advance in the first instance, the public would respond and co-operate. They are not insensible to the advantages of the observatory, which supplies them with a system of Greenwich mean time, regulated by electricity, upon a more extensive scale than is to be found in any provincial town of the United Kingdom.

12,285. Would you recommend that it should be done by the combined aid of the State and local contributions, rather than by a grant exclusively from the State?—I think that the principle of combined aid should be followed out.

12,286. Can you say what amount you think would be required?—I have not formed an estimate of the amount.

12,287. But you have mentioned additional officers that would be needed?—Yes.

12,288. (*Sir J. Lubbock.*) You mentioned that the salary of the professor of astronomy was, I think, 50*l.*, but that it was held in conjunction with some other appointment?—With a supplementary grant of the University to the extent of 220*l.*

12,289. May I ask whether there is any other post which is, in the present case, or usually, held in conjunction with it, or is that the whole amount of the salary?—Almost the whole amount. The recent allowance from the Board of Trade in connexion with the meteorological observations, which amounts to 250*l.* annually, supplies a small sum in addition, but for the working of this department two assistants are required.

12,290. Who are paid out of the 250*l.*?—Yes. Then there are expenses for chemicals, gas, water, wax paper, and other items, all of which, with the

R. Grant, Esq., LL.D., F.R.S.

21 June 1872.

expense for assistance, leave only a very small margin of the allowance for superintendence. Under these circumstances, the income of the professor is necessarily made up by literary work.

12,291. (*Chairman.*) Are there any additions which you wish to make to the evidence which you have given on any other points?—No, I am not aware of any.

The witness withdrew.

J. S. B. Sanderson, Esq., M.D., F.R.S.

J. S. Burdon Sanderson, Esq., M.D., F.R.S., examined.

12,292. (*Chairman.*) You are Professor of Practical Physiology at University College, I believe?—I am.

12,293. And also Director of the Brown Institution, connected with the London University?—I am.

12,294. Will you be so good as to state to the Commission your views as to the present position of physiology in this country, and also as to the means to be adopted for its improvement?—The first point that I have to draw attention to is this, that in England the obstacles to the carrying out of physiological research are principally those which concern the persons who are engaged in such research. I believe that in all countries, and at all times, physiological research must be conducted by people who are more or less connected with the medical profession, either in the way of teaching or in the way of practice. Formerly, the two things were inseparably associated together. But, during the last 20 or 30 years, a great change has taken place in the state of things in that respect, in consequence of which physiology has become more and more an experimental science, and, therefore, has passed more and more under the influence of the exacter experimental sciences, namely, chemistry and physics, and the result of this is, that the work is now done more in the laboratories than it used to be formerly.

12,295. Will you put us in possession of your views as to what you understand by the term "physiology?"—I understand by the term "physiology" the application of physics and chemistry, or physical and chemical methods, to the investigation of the phenomena of animal and vegetable life. I exclude morphology, paleontology, zoology, and botany, with reference to which subjects I am not competent to speak.

12,296. Will you explain the great change which has taken place in the subject of physiology during the last few years?—The science, by virtue of its own progress, has become more experimental, and has thus passed under the dominion of physics and chemistry, and, consequently, physiologists are now not merely physicians and surgeons, but they ought to be chemists and physicists, because the methods which are practised in the chemical and physical laboratories are just those which are necessary for the investigation of physiological questions. In Germany, where physiological research is now carried on very much more successfully, and on a very much larger scale, than it is in this country, the physiological workers belong to two classes of men, both of whom are connected with the medical profession. Those of the first class are teachers or professors of physiology, and they constitute a class which is not fully represented in this country, for those who are engaged in teaching physiology in our medical schools in England do not correspond in their character altogether to the teachers of physiology in Germany, because, although, in some of the largest schools, physiology can be taught experimentally, and taught in a laboratory, yet there are a great many much smaller schools, where those who are engaged in teaching are also principally engaged in other occupations. The result of this is, that the teachers themselves are not what is understood in Germany as scientific men, or what we should understand as scientific men either, but merely book learned men—men who have become acquainted with physiology by reading. The men of the second class may be designated as student workers, that is to say, gentlemen, well-trained in the methods of physical and chemical work, who are willing to devote themselves for a certain number of years to scientific research of a purely physiological kind, and to work under the direction of the professors. Almost all the great researches that have been made in Germany have been made by a combination of those two classes, that is to say, the work has been done by young men, while men in the position of professors have superintended the work. And it appears to be clear that in England, if physiology is ever to be carried out successfully, it must be by the same agency, a combination of students and teachers of medicine.

12,297. What, in your opinion, are the circumstances which chiefly prevent the prosecution of experimental research by students and teachers of medicine in this country?—I would allude, first, to the unfavourable tendency of public opinion. The scientific man is not estimated as he is in Germany, nor is he, on the whole, estimated so highly as the practical surgeon or physician. The unfavourable condition of public opinion acts particularly on young men who, at an early period of life, are deterred from engaging in scientific careers, because such careers are not only not so profitable, but the due amount of credit is not awarded to them by the public.

12,298. As to this first point, with respect to the tendency of public opinion, it is a very difficult matter, is it not, to influence, in any way, the general current of public opinion?—Quite so.

12,299. Have you any recommendation to make upon that point?—No.

12,300. Will you go on to your next point?—I would refer to two disadvantages which more or less affect students, understanding under the term "students," not merely "students" in the strict sense, but young men who would belong to the same class as those who engage in research in Germany, either men who may be considered as aspirants, or men who, for a certain number of years, devote themselves to science with the intention of quitting it at a later period. One of those circumstances is, that during student life an immense deal of time is occupied in London in competing for honours of various kinds, particularly for University honours. It is not merely that the time is occupied in this way, but that it sets up a very different standard from that which exists in Germany. Honour is given to book-work instead of being given to research. There is no doubt that, even without reference to the actual time that is taken in preparing for examinations for honours, the influence of that principle has a very great effect upon young men. They set up that standard instead of the right standard; I mean the standard of attainment by book-work, instead of the standard of scientific work or investigation. Then another evil is one which, of course, cannot be remedied at all, or not very readily remedied, namely, that our young physicians and surgeons are very largely called upon, by the actual state of things in our hospitals, to devote an immense deal of time to the pure drudgery of hospital work, and the result of this is, that, during the first half a dozen years of a physician's or a surgeon's life, he is prevented giving that time to scientific investigation which he would otherwise do. These are facts which I think account, in some measure, for the difference which exists between Germany and England as regards the occupation of young men in scientific work.

12,301. With respect to the first circumstance to which you alluded, should you like to see any alterations introduced in the system of competition for University honours?—I am of opinion that honours in medicine are a mistake altogether; that it is a mistake for men to be occupied in attempting to obtain distinction in that way; that their time and labour and energies would be better spent otherwise.

12,302. Will you proceed to state in what way you consider that money might be applied for the pro-

J. S. B. Sanderson, Esq., M.D., F.R.S.

21 June 1872.

motion of physiology?—I consider that it might be available for three purposes; namely, for the improvement of laboratories, for the providing of instruments and materials for research, and for the remuneration of workers. I will speak first of the spending of money upon the improvement of laboratories. I do not, myself, see at the present moment that we are in a position to require the expenditure of large sums of money upon the building of large laboratories, for this reason, that if such laboratories were built, we should not have workers to work in them; at present we have not men to work in the laboratories that we actually possess. We have men of a certain class, but we have not men of that trained class which we require. I am of opinion that a physiological laboratory, to be of any use at all, must be in connexion with the great schools of medicine. A physiological laboratory, at a distance from such schools would fail for want of people to work in it. Physiology will never flourish, therefore, excepting in connexion with the two arts which are dependent upon it. Just as vegetable physiology will flourish best in connexion with agriculture, so also animal physiology will flourish best in connexion with medicine. I think that grants might be very advantageously given for the improvement of the laboratories now existing. Of course, in the administration of such grants, one would go upon the principle "to him that "hath shall be given;" that is to say, wherever a good laboratory exists, or wherever men are to be found to work a laboratory, and where there are likely to be students to work in it, money should be given to carry out improvements. I would further notice that, in physiological researches, the expenditure for materials is usually much greater than for instruments, and, consequently, money is more wanted for current than initial expenses; for this reason, large sums ought not to be expended in the purchase of collections of costly instruments, for if such sums were spent they would probably not be used. It is much better to provide money to assist to meet those heavy expenses which are required for material. To show this, it would merely be necessary to refer to some of the physiological researches which are being now carried out, in which a great expenditure is required for material, but no tremendous expense for instruments. Of course I do not mean to say that it is not necessary to spend money on instruments, but any expenditure on a large scale for this object would be very likely wasted. On the whole, I believe that money can be more economically spent in sums paid for work done than in any other way, *i.e.* either in the way of periodical payment to men of acknowledged competency, for the purpose of carrying out inquiries of long duration, or in the form of separate grants for special researches, or in the form of grants for skilled assistants. With regard to grants for skilled assistants, I must explain what sort of persons would be the assistants. The assistants would be men belonging to a class to which I have already referred, the class of students and aspirants, that is to say, students in the strict sense and students in the less strict sense, young physicians and surgeons willing to devote themselves to science for a certain time. To such men it would, undoubtedly, be a great inducement, if it were possible to partially remunerate them for their services, to induce them, instead of occupying themselves with other pursuits, which, perhaps, are more or less remunerative, and serve to enable them to live for a certain time before practice comes, to engage, as they do in Germany, in research work. Of course, in Germany, men who do this work are not paid, and it is very necessary to bear this in mind, but the difference there is, that such men have something to look forward to. There are in Germany numerous teaching appointments to which a man can look forward with the certainty that, if he works industriously for a certain time, he is sure to get an appointment of some kind afterwards, which will enable him to take the position of a professor. This state of things does not exist in England, and, therefore, it is more necessary in England to encourage the younger men to engage in research by pecuniary aids than it is in Germany.

12,303. Are there any considerable number of schools or institutions for medical purposes in this country which you think it might be desirable should be assisted in the way that you have suggested?—I think there are about four in London in which the apparatus for teaching physiology exists in such a state of efficiency that it would be worth while giving that assistance. Clearly, to assist the smaller schools would be a great waste of money, because, in the first place, the teachers are wanting; secondly, the students are wanting; and, thirdly, the buildings are insufficient. But in, perhaps, four of the largest schools in London the appliances, so far as they relate to buildings, exist in greater or less perfection.

12,304. Are there any similar schools in Scotland and Ireland, or in the provinces, which you think are of sufficient importance to deserve such assistance as you have referred to?—Certainly. In Edinburgh, for example, in the University, there is already a physiological laboratory which is well provided with appliances for research. Manchester is the best example that I could mention of a provincial school. At Manchester they are now providing themselves with scientific apparatus for the purpose of teaching physiology effectually, and no doubt, in a short time, they will be able to engage in research under quite as favourable circumstances as the London schools.

12,305. Would the London schools, generally, be able to do more in the way of promoting original research if they had larger funds at their disposal?—I am quite certain that as regards the larger schools, where there are men who are competent, that is really what is immediately required.

12,306. (*Dr. Sharpey.*) Speaking of the rewards now attainable through competition by students, such as scholarships and the like, and which are now given chiefly for proficiency in mere book-work, do you think that it would be practicable to assign these for original research?—I think it would be perfectly practicable. I think that it would be an excellent way of furthering the doing of work by men of this particular class.

12,307. Do you not think that, besides young men belonging to the medical profession, there might not be a class of students who eventually might become teachers of physiology in the higher schools of this country?—I must make it perfectly understood that I did not think that every young man who worked at physiology was to become a physician or a surgeon; on the contrary, I contemplated that the best and the most able of those young men would become teachers, and would occupy themselves entirely as you propose, and would enter the profession of science, and not the profession of medicine.

12,308. You mean that they might become teachers of physiology in other institutions than medical schools?—Possibly so.

12,309. For example, the great public schools and the advanced endowed schools?—I have no doubt that the men who have done research are better for the teaching of the most elementary physiology than the men who have not done it.

12,310. (*Professor Huxley.*) With respect to the necessary connexion between the scientific study of physiology and the medical schools, do you not think that in the course of time physiology is likely to detach itself as much from the art and practice of medicine as chemistry and comparative anatomy have done?—The contrast between chemistry and physiology in this respect is a very striking one, I think. Chemistry has entirely detached itself from medicine, although it was formerly as closely connected with medicine as physiology was for many years afterwards. The reason, I think, that physiology will not detach itself from medicine is, not that the two studies are not perfectly separable as studies, but that the men who are interested in working at physiology and are willing to devote their lives or parts of their lives to it, are always men who have a practical interest in it.

J. S. B. Sanderson, Esq., M.D., F.R.S.

21 June 1872.

Comparative anatomy was originally entirely connected with medicine and the medical schools. But it has now, without any distinct practical bearing upon it, become a study by itself. It may be very possible that physiology may take the same rank; but I think it is not likely, for this reason, that medicine will, undoubtedly, in the progress of time, become more physiological; for, although now in treating disease we are obliged to regard medicine merely as an art, yet at some future period unquestionably it will come much more under the influence of science than it is at present; and the science under which it will come will of course be physiology, and that will tend to draw together again the two subjects, even if they are for a time separated.

12,311. But, so far as the practical connexion of scientific physiology with medical schools is concerned, is it not almost impossible, considering the amount of time which medical students have to devote to their purely medical studies, that they should ever be able to know, thoroughly, more than the general results of current physiology, and must not any institution for the advancement of physiology by its locality be practically independent of the men who are working at medicine?—The teachers of physiology must be practically independent, that is to say, they must be men who are devoted entirely to physiology, and the business of whose lives it is to be physiologists and to be nothing else whatever; but the work of physiology may be done, and probably will always be done, not by teachers alone, but by teachers with the co-operation of young men, that is to say, young men who are not necessarily scientific men by profession, though, if they show great aptitude for science, they may probably become so. I feel perfectly certain that the great progress which has been made during the last 20 years in Germany is quite as much dependent upon the fact that the young medical men work at physiology, under proper guidance during their earlier years, as that there are able professors to guide them.

12,312. I imagine that you would have no objection to seeing physiology become a branch of general education?—On the contrary.

12,313. Supposing it to form a branch of general education, it would be necessary, would it not, to have trained teachers to give instruction in physiology?—Yes.

12,314. Under those circumstances would there be any objection to having an institution in which that training is given quite apart from the large medical schools, or would there be any advantage in connecting it with medical schools?—I think that it would be quite possible to have such a training institution, but such institution would not be an institution for research, and I am only speaking of research.

12,315. But, in such a case, would not the same rule hold good, namely, that while the persons who are brought there to be instructed should simply be informed in the main results of the advanced knowledge of the time, it would be very desirable that the persons who taught should have the means of advancing that knowledge, and that if the medical school appears to hold good for a general training place, if it be an advantage to a teacher in a medical school to have the means of pursuing original research, it is surely an advantage for any teacher to have it, and his teaching is likely to be good in proportion as he has that knowledge?—It depends very much upon what the purpose of the training school is. If the training school is to be anything more than a place for acquiring a thorough elementary knowledge of physiology, then, of course, research may be contemplated; but, surely, if the business of the place is to be elementary teaching, that is not quite so favourable as, for example, a medical school would be for research.

12,316. From your knowledge of medical students at present, I think I may venture to expect that you will agree with me that the knowledge which medical students have may be called elementary knowledge?—Extremely elementary; in fact, not even elementary in some cases.

12,317. All I meant to suggest was, that the argument which provides the one place of instruction would provide the other, that if it were advisable to have the means of investigation for the benefit of the teacher, in the one case, it would be advisable to have it in the other?—But there is another strong argument, namely, that it is absolutely necessary for the welfare of society that medical men should be thoroughly well taught, and that investigations should be made in connexion with medicine, and certainly it is not necessary that investigations should be made in connexion with general education. We know that there is nothing more likely to promote work, on the part of a young man, than his being in relation with persons and being in places where serious research is going on. That is another ground, I think, why medical science should remain in closer relation with physiological research than any other subject.

12,318. I am not suggesting that it is not desirable to have laboratories for original research in connexion with the medical schools in which physiology is taught. I am merely asking your opinion whether, supposing there was a place in which physiology was taught for general purposes, it might not be desirable to have the means of original research connected with the teaching of the institution?—I think that if there were any teacher there who was engaged in original research, and who was capable of carrying it out, the same advantages ought to be accorded to him as if he were teaching in connexion with a medical school.

12,319. His teaching would be much better for having a means of research than that of a medical teacher would be?—I have no doubt of it.

12,320. Do not you think that one of the best practical means of getting medical professors better taught in the elementary grounds of their science is to teach the public. I mean that a great deal of the twaddle which now passes current between medical men and their patients could not pass current if their patients knew anything about the subject?—I have no doubt of it.

12,321. (*Dr. Sharpey.*) In the evidence you have given as to the propriety of aiding physiological laboratories connected with medical schools, had you not in view that there are such laboratories now existing?—I had that in view.

12,322. And very likely there will be more connected with medical schools, whereas, I am not aware that there is any physiological laboratory for the teaching of general students?—I would sum up what I said just now as to the grants to individuals for researches in connexion with laboratories by the statement that wherever an efficient laboratory exists and an efficient man to work in that laboratory, there a proper case is made out for a grant, whether he is teaching with a view to medicine, or with a view to other objects.

12,323. (*Professor Huxley.*) Have you not a considerable physiological laboratory at the Brown Institution?—A pathological laboratory. We confine ourselves entirely to researches which bear upon disease.

12,324. That is not connected with any medical school, is it?—It is not connected with any medical school.

12,325. (*Chairman.*) Although physiology, in Germany, as in this country, is chiefly connected with the medical profession, is physiology regarded more as a branch of general education than it is here?—I do not think so.

12,326. (*Sir J. P. Kay-Shuttleworth.*) Is not the distinction between the two countries mainly this: that in Germany, owing to a number of social causes, there are more men disposed to devote themselves to either purely literary or purely philosophical pursuits, with a low rate of remuneration, than there are in this country?—We must admit that to be true, but still I think it is dependent upon causes which are partly removable and partly may not be removable. I admit that there is a great difference, in that respect, between Germany and this country.

12,327. Could you make any suggestion as to the

J. S. B. Sanderson, Esq., M.D., F.R.S.

12 June 1872.

mode by which we could hope to create in this country a spirit resembling that which you conceive exists in Germany, but which does not exist here, as to the preference for a purely philosophical career to that of a practical career in any profession?—One want is money, which should be spent, as I have endeavoured to state, namely, partly in encouraging young men and partly in encouraging professional scientific men in the work which they are already engaged in.

12,328. A young man may, in his early career, have a very earnest devotion to purely abstract science: he may, for example, be a very able demonstrator or assistant in a laboratory, but a time comes when, if he be a physician, he has to earn fees, and so much of the early promise of his youth, with respect to science, evaporates in the practical pursuits of a physician or a surgeon. Can you suggest any remedy for that?—I should not like to remedy it altogether, because I think it is necessary for the progress of physiological research that there should be a number of young men engaged in it who should be properly trained, and should be willing to work under the supervision of men who devote their whole lives to the subject. I am quite sure that the value of such work would be great.

12,329. Would it not be desirable that there should be more men in this country who would devote their whole lives to science?—Decidedly so.

12,330. It is in that way that my question was framed, whether you could point out any expedient to be adopted, either by the State or in general education, which would lead to such a result?—The way to remedy that, I think, would be to give assistance, in scientific work, to men who are already engaged in scientific work. That is the principle which I think ought to be followed, and the principle which, in this country, is most likely to act favourably.

12,331. Is there not one thing which probably operates against it in a country which is amassing great wealth, that the ordinary means of living are much more costly in this country than they are in Germany? — I quite feel that. Of course I am perfectly aware that a scientific career in this country can never be even a moderately profitable career. But all that we really want is, that scientific men should be in such a position that they may not feel the inconvenience of poverty. I do not at all look forward to the scientific profession being a well-rewarded profession, as compared with others.

12,332. But, if such a young man has to choose between comparative poverty or wealth, or the possibility of comparative poverty or wealth, at a certain period of his career, is not that a motive for increasing at least the chances of a sufficient income to a professor of abstract science?—Certainly, I think it is a very strong argument indeed. I think that scientific men ought to be protected by the State from comparative poverty.

12,333. Does not this consequence almost obviously follow, that, in a country like England, which is so immensely more wealthy than Germany, the rewards to men who devote their lives to abstract science should be proportionately greater?—I think that follows certainly.

12,334. (*Dr. Sharpey.*) Could you suggest any course to be taken in this country which would supply a career for those young aspirants that you speak of, something analogous to what is offered in Germany through the appointment of professorships, assistant professorships, the office of *privat docents*, and the like, in the numerous German universities; do you think, for instance, that if there were a class of teachers of physiology in general schools apart from the medical schools altogether, that might not furnish a career to some of these young men, and an inducement to them to pursue physiology?—It might do so, but I do not quite see how the position of a teacher in a public school could be made sufficiently attractive in this country, but I may be mistaken.

12,335. (*Professor Smith.*) Is it not the case that, in this country, the teachers of those branches of science upon which medicine is dependent, and more particularly the teachers of physiology and chemistry at the great medical schools, are less remunerated for their services than other classes of scientific teachers? —That depends entirely upon the size of the schools, the teachers being remunerated according to the number of students; they are better remunerated, of course, in the larger schools than in the smaller schools. In the smaller schools the remuneration may be considered as nil. The teaching of physiology is carried on by young physicians or surgeons who do not care anything about physiology, who may take that subject as happening to be vacant, perhaps, in the teaching of the school, and who have no idea of pursuing research, either then or at any future period, but intend, as soon as they can get an opportunity, to teach something else, some practical subject, and to go in for practice. In the larger schools, of course, there is a certain amount of remuneration, as, for example, in St. Bartholomew's, where the appointment of a teacher of physiology is of a certain value, but still it is not of sufficient value to enable a man to live by it, at all events not in London.

12,336. If persons of that kind were better remunerated, and there were more of them, would not that induce young men of the kind that have been referred to, to prefer a scientific life, and the life of a teacher of science in some cases, to the practice of a profession?—I think so.

12,337. If those places could be rendered more attractive and really sufficient for a man to live upon, that would be one means of diverting a certain number of young men from the practice of the profession into scientific life?—That is one of the means which I suggest, the encouragement of men who are already teachers, by improving their position pecuniarily; the other is the encouraging of young men, in the condition of the aspirants, of whom we have been speaking. Those are precisely the sort of men that I would like to see assisted, provided, of course, that assistance is only given to men really competent and men really of a scientific character; because, it may happen that even in our large hospitals you may have a man holding a position as a teacher of physiology who is not a physiologist at all, and would not assume that character.

12,338. (*Professor Huxley.*) With regard to a practical method of remedying the evils which arise from the present very small reward which most teachers of physiology obtain; there are, at present, I think, about 11 medical schools in London, and it follows from that dividing of the total number of students by 11, that there must be a number of chairs of physiology out of that total number of 11 which must be very badly paid; would not the shortest practical way of remedying that evil be to reduce the number of schools in which physiology is taught, probably to some three or four institutions? — No doubt that is a matter of the utmost importance, practically, for the progress of physiology.

12,339. Has any movement been made towards bringing that about?—Various movements have been made between different schools for the purpose of combining them, but no general movement has been made. The most feasible plan for that purpose is, of course, to separate practical teaching from scientific teaching; that is to say, to have all of our students in London educated in one or two places as regards those scientific subjects.

12,340. (*Sir J. P. Kay-Shuttleworth.*) You would extend that, would you not, to other branches of science connected with medicine, besides physiology, so as to have better laboratories and better means of instruction for them?—Yes.

12,341. You would have a central scientific school for the various medical schools, the schools themselves being chiefly devoted to the application of the science to the art of medicine? — Yes, and I believe that everyone who knows anything about medical education wishes it too, only there are great difficulties in the way.

J. S. B. Sanderson, Esq., M.D., F.R.S.

21 June 1872.

12,342. (*Chairman.*) Are there great practical difficulties in bringing about such a result?— There are very considerable difficulties.

12,343. Have most of the larger hospitals a physiological school attached to them?—Every hospital that has a medical school has a teacher of physiology; but in some of the schools there are only a very small number of pupils, and there are no means of teaching it efficiently.

12,344. What are your views as to the importance of any grants from the Government for work done, or for apparatus, or for other expenses, and as to placing medical schools under the supervision of a council of science?—I am strongly of opinion that there should be a council of science. As to the size of that council I do not feel very strongly. All that I feel is, that it is most important that all who are on that council should be men of a purely scientific character; and on this ground I am of opinion that it would be more convenient to have a small council than a large one; because, I apprehend that it would be difficult to find men of the attainment required to fill the places in a very large council. What I would wish to emphasise with regard to that is, that no one should be on the council who is not distinguished by the extent and the purely scientific character of his own researches. No one should be on the council who has not himself done research, and whose researches have not been of that kind.

12,345. Would you leave the selection of the members of the council to some member of the Government?—I have not directed my attention particularly to the mode of electing the council.

12,346. You have no guarantee to suggest which you think would secure the appointment of the best persons to serve upon such a council?—I do not know any guarantee excepting publicity.

12,347. Would you like to see them recommended by any of the scientific societies, the Royal Society or other societies?—We have all perfect confidence in the Royal Society, and know that any personal recommendations that the Royal Society made would be impartial.—Another point that I should like to dwell upon is this, that it is not necessary that every science which requires encouragement should be represented; for example, the physiologist might depend with perfect confidence on the chemist or physicist, and be quite sure that he would form a perfectly correct opinion as to the judicious administration of money for physiology; whereas, he would not have any such guarantee if there were persons taking part in that council who were not themselves scientific men.

12,348. Do you think that the services of such a council would be called into frequent requisition?—That would depend upon the funds that they had to administer. I suspect that if the principles I have advocated were adopted, and if their function were to be to encourage research, they would always have a good deal to do. I presume that they would also have a good deal of a judicial function, that is to say, they would not only have to direct the administration of the money, but they would have to do a certain amount of work in the way of inquiry themselves, or, at least, of judging of the value of results.

12,349. Would you contemplate that it would be their duty to initiate proposals, having for their object the advancement of science, or merely to give advice when called for from the Government?—I should think that there ought to be facilities for the initiation of proposals; that they ought to be competent to initiate proposals, although, of course, that initiation would often be suggested by opinion outside.

12,350. (*Professor Smith.*) I gather that you think it of great importance that the council should consist exclusively of scientific men, but that I understood was because you consider that only scientific persons, who themselves knew what research was, were competent to decide what researches should be encouraged, and what were really valuable researches; but if other duties should be assigned to the council, if, for instance, it should have to advise the Government upon matters that were partly administrative as well as scientific, you would no longer think it necessary, would you, that it should consist entirely of scientific men?—I see no objection to the council including members not of a scientific character, provided it were understood that those members did not hold seats in the council as scientific men. Those who hold the position of scientific advisers should be themselves competent to advise on scientific subjects. I do not see any objection to the council also including members who, without pretending to know anything of science, or taking part in the discussion of the scientific questions that would be before the council, would take a part in administrative questions. That appears to be quite possible. The point is, that we should have no one taking part in the proceedings of the council in their scientific character excepting persons of the highest scientific position.

12,351. (*Dr. Sharpey.*) You would rather trust physiology, for example, to an eminent chemist and physicist than to a mere physician, however eminent?—Certainly, or in any corresponding subject.

12,352. What mode do you think should be adopted for the payment of the council; should it be by a fixed salary, or according to the task that they have to do?—I think if the council were a small council, the remuneration would have to be considerable. It would be very much better to pay them well for doing their work thoroughly, than to remunerate them at a certain rate for irregular work. I suppose the best mode of payment, and it is a very usual mode of payment, would be payment for attendance for each meeting of the council. I presume that would be the most efficient way of remunerating them.

12,353. (*Chairman.*) Do you think that the Government might experience any serious difficulty in selecting six or seven scientific persons as members of the council whose appointment would command general confidence amongst men of science?—I believe that there would be very little difficulty in their selecting six or seven, but very great difficulty in selecting 30.

12,354. Should you like to see such appointments held for life, or for a term of years?—I have not thought of that question sufficiently to give an answer.

12,355. (*Dr. Sharpey.*) Have you considered whether it would be advisable to have a minister of science or a minister of science and instruction, or a permanent under secretary in some existing department of the Government in communication with this council of science?—I have no doubt that it would be necessary to bring the council of science into relation with some one minister, just in the same way as in Austria, for example, assessors on different scientific subjects are in communication with the minister.

12,356. Has the minister who has charge of science in Austria charge also of education?—Yes.

The witness withdrew.

Adjourned till Wednesday next at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 26th June 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, Esq., M.D., Sec. R.S.
GEORGE GABRIEL STOKES, Esq., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, Esq., M.A., F.R.S.

ALEXANDER BUCHAN, Esq., F.R.S.E., Secretary of the Scottish Meteorological Society, examined.

A. Buchan, Esq., F.R.S.E.

26 June 1872.

12,357. (*Chairman.*) You are Secretary of the Scottish Meteorological Society?—Yes.

12,358. That society I believe was founded in the year 1855?—Yes.

12,359. Has it a large number of members?—560 at present.

12,360. Are the number of members gradually increasing or about stationary?—The first three years, the number was about 186. Then they increased slowly until about 1864, when there was a rapid increase. There were nearly 600 for two years.

12,361. What is the amount of the annual subscriptions of the members?—About 400*l.*

12,362. I presume that the business of the society is conducted in the usual manner of scientific societies, by a council?—Yes. During the last three years 31 meetings of Council have been held, the actual average attendance being 10.

12,363. Has the society any other sources of income beyond the subscriptions of the members?—None, except the profits arising from the sale of the society's journal to the public. Members receive the journal gratis.

12,364. Can you furnish the Commission with the income and expenditure of the society?—Yes, for the past year, ending 31st May 1872, it is as follows:—

INCOME.

	£	s.	d.
Annual subscriptions - - -	£396	19	0
Life ditto	59	17	0
Sale of journal and advertisements; balance of publisher's account	22	6	5
	£479	2	5

EXPENDITURE.

	£	s.	d.
Salary of secretary -	£198	11	0
Allowance to treasurer's clerk	24	16	4
Journal of society -	101	14	0
Printing, engraving, and stationery -	31	12	0
Books purchased and bound	33	17	2
Instruments - -	5	9	6
Postages of schedules, journal, letters, &c.	32	13	0
Advertising meetings - - -	5	13	9
Visiting stations - -	2	8	0
Rent—			
Paid to Government - -	30	0	0
Cleaning, coals, &c. - -	12	4	7
Balance - -	0	3	1
	£479	2	5

The only remark that I would make about the above is, that it may be regarded as a fair specimen of the year's income and expenditure, excepting the sum for book-binding. The library was put in order at a cost of 26*l.*, an outlay which will not recur.

12,365. Do you usually expend your whole income in the course of the year?—Yes.

12,366. Was the object of the society to establish stations for the purpose of meteorological observations?—Yes. If the Commission wish a brief statement of the objects of the society, they are stated in the following paragraph of a circular which was recently issued by the Council:—"The principal points aimed at since "the commencement of the society's operations in 1855 "are, to investigate Scottish meteorology, in order to "ascertain the character of the climate of different districts, the causes of the summer and winter peculiarities, and the differences between the climate of "Scotland and that of other countries; to point out "the influence of seasons on public health, and on the "prevalence of diseases afflicting crops and live stock; "and to investigate the origin and progress of storms, "and the general laws affecting atmospheric changes, "the discovery of which might lead to a knowledge of "the coming weather."

12,367. How many stations do the society keep up?—At present upwards of 90. That has been the number for a few years; it began with 33 in 1855; rose to 42 in the beginning of 1857, and to 55 at the close of that year, at which point it remained stationary for a few years. In 1863 an increase took place,—certain inquiries having been taken up in connection with the Medico-Climatological Department, the discussion of European storms, and various other questions which it was thought desirable to inquire into.

12,368. What instruments or apparatus are the stations supplied with?—A barometer, dry and wet bulb thermometers, maximum and minimum thermometers, and, in many cases, two sets of maximum and minimum thermometers for shade temperature and exposed temperature, a rain gauge, a box for holding the thermometers of a particular pattern of a louvre boarded box, a wind gauge, a wind vane, and, in a number of cases, a sea thermometer, a well thermometer, three thermometers for underground temperature, and ozone test papers. But what we regard as the essential instruments, which they must all have, are the barometer, the self-registering thermometers, wet and dry bulb thermometers, and a rain gauge.

12,369. Are some of the stations more fully equipped than others?—Yes.

12,370. Does that depend upon the society or the observer?—It depends upon the observer mainly, but the Council have, from the first, used their influence with observers and local parties to have the stations supplied with all the instruments; and they have occasionally given grants of one instrument "or a complete set" to poorer observers. It may be mentioned that, at several stations, there are double sets, in the event of injury.

12,371. Are you able to speak as to the value of the instruments at those stations?—Yes; I have made a careful estimate, so far as could be done, and the value of them is 1,135*l.*—an estimate which cannot be far from the truth. Of this sum 200*l.* belongs to the society and 935*l.* to private persons in connexion with the society, some of them being comparatively poor men, who have bought their own instruments.

12,372. In addition to this 200*l.* does the society possess any other property?—Yes; the furniture in the office, and instruments to the amount of 236*l.*, exclusive of the library, which contains upwards of

A. Buchan, Esq., F.R.S.E.

26 June 1872.

600 volumes, nearly all of them being works on meteorology, and a very large collection of pamphlets exceeding 2,000, many hundreds of maps and charts of a meteorological character entirely, a large number of manuscripts of various sorts on special subjects, and weather observations extending from 1767 down to the present time. We have endeavoured to secure as many of those old weather manuscripts as we know to exist, and we either have the use of them or they belong to us.

12,373. Are any of your observers paid?—None.

12,374. What sacrifice of time does it involve on the part of the observers?—Not so very great a sacrifice of time; probably from 5 to 10 minutes at 9 in the morning, and three or four minutes in the evening, provided the observer does not require to walk far; but the chief sacrifice is punctuality at a particular time, and that is no doubt a considerable sacrifice. Two or three hours are also required each month for filling in the daily observations in the monthly schedule.

12,375. Are the observations made daily?—Yes, twice a day, and sometimes, in the case of any remarkable phenomenon occurring, such as a storm, heavy rain, or anything which arrests the attention of the observers, observations are made every hour or oftener, sometimes every quarter of an hour; there are a number of the more zealous observers who do so.

12,376. Do the greater part of the observers take a personal interest in their work?—They do; a few of them, especially those who are gardeners, when they are engaged, are told that the work of observing is a part of their duty. I should say, however, that three-fourths of the whole observers are men personally interested in the subject.

12,377. Have you been obliged to discontinue any stations from the difficulty of finding observers?—Yes, for example, the Perth station has been discontinued for the past nine months, since the death of Sir Alexander Lindsay, who was the observer there. In such cases the Council lose no time to find some one to supply the place as soon as possible.

12,378. Have the objects of the society been in any respect seriously interfered with from the discontinuance of any of the stations; has the value of the observations been diminished?—Yes, to some extent, as regards particular inquiries. Portree in Skye ceased some time ago, and Dunvegan was got, about a year or a year and a half afterwards, to take the place of Portree; but a large blank was left in the map of Scotland by the suppression of Portree, and in some storms and inquiries of the weather it was not possible to make the inquiry so complete as it would otherwise have been. Tyndrum, in many respects a very important station, ceased to be one in 1862. We have not yet been able to resume observations at this station, nor, indeed, at any point on or near the watershed of the West Highlands, the meteorology of which, from the excessive rainfall and other peculiarities, it is so desirable to know.

12,379. With respect to the stations which are not in Scotland, has the society received any assistance from the Government?—Yes, considerable assistance. We were liberally assisted in establishing most of those stations by a loan of instruments from the Board of Trade on the recommendation of the late Admiral FitzRoy, who was a cordial friend of the society. Since the appointment of the Meteorological Committee these instruments have been presented to the society by the committee, but with the intimation that no more instruments would be granted to the society by the committee. We were told that we were not to look to them for any further assistance. Previously, in establishing most of our valuable stations in Iceland and Farö, at North Unst in the Shetland Islands, at Monach in the Hebrides, at St. Kilda, at the Calf of Man, at all the Syrian stations, such as Jerusalem, Damascus, Beyrout, and at Yanina in Greece, when the wish on the part of the council was conveyed to the Board of Trade to have stations established, we practically got what we wanted, and in that way our operations were very materially forwarded. I think the value of the instruments sent to such places as the Iceland and Farö stations, and the others, would be about from 12 guineas to 14 guineas each station, including louvre boarded boxes for the thermometers, which were supplied at the expense of the society. With regard to establishing new stations, where we have men willing to observe but unable to bear the expense, the society are unable to bear such expense, and valuable stations are thus lost, from our inability to supply the instruments.

12,380. (*Professor Stokes.*) Are the observers at the Syrian stations, for instance, paid?—No, we have no paid observer. I understand that there was once one of our observers paid by the Duke of Roxburghe, but never by the society.

12,381. (*Dr. Sharpey.*) What description of persons do you find in Syria for those observations?—We have the Consul-General for Syria at Beyrout, Mr. Eldridge, Dr. Chaplin at Jerusalem, Mr. Sandwith at Larnaka, in Cyprus, who is Vice-Consul for the island, and in Damascus we had the Consul there, Mr. Rogers, but he left Damascus three or four years ago.

12,382. (*Chairman.*) Do you follow any particular system in your stations beyond Scotland, or do you take advantage of opportunities as they present themselves?—A medico-climatological committee was appointed by the society in 1863, owing to the many inquiries that were made at the office for information with regard to Sanitaria, to which invalids go, chiefly by physicians or the friends of those invalids. Those inquiries we were in some cases able to answer, but in many cases not; and the stations that were then established were at those places to which invalids had been accustomed to be sent. The observers whom we got were medical men there. The late Dr. Scoresby Jackson and Dr. Arthur Mitchell were chiefly instrumental in getting the observers, who were for the most part their own personal friends. As regards the stations in Syria, our late honorary secretary, Dr. Keith Johnston, was there in 1863, and being very anxious to obtain some trustworthy information on the climatology of Syria, he secured for the society the services of the observers already referred to. The stations in Iceland and Farö, North Unst, Monach, in the Western Hebrides, and St. Kilda were established owing to a very strong conviction on the part of the council that in working out the problems of the weather and storms of Great Britain and Europe we were very seriously in want of information from the west and the north of Scotland. We found that the centres of those great atmospheric disturbances that we had to deal with were in the great majority of cases north of Scotland; and to fill up this blank and get this indispensable information those stations were established, after communication with the Board of Trade, who liberally gave us the loan of whatever instruments were required,—Admiral FitzRoy at the time going heartily into this project of the council. So far as Iceland was concerned, the observers who were secured there were personal friends of Mr. R. M. Smith, one of the members of the council, a Leith merchant and shipowner. The station in Farö was secured to us through Mr. R. Tennent, another member of the council, along with Dr. Keith Johnston, and the then governor of the island, Mr. Holten, who very heartily entered into the subject. I have brought a book with me which shows one year's observations at half of our stations, in order that the Commissioners may examine it, and see the sort of work that is done by the observers.

12,383. There is now no distinction between the foreign stations and those in Scotland, that is to say, they are not assisted by the Government in any way?—In no way is any of the society's stations assisted by Government.

12,384. Are all your stations conducted by British subjects?—In Iceland and Farö they are Danish subjects.

12,385. Have you any communication with the governments of those respective countries?—Before we established the stations in Iceland and Farö there

A. Buchan, Esq., F.R.S.E.

26 June 1872.

was some communication, through Governor Holten, with the home government of Copenhagen, but they refused to undertake the matter. I believe, however, that the Danish Government are now about to establish stations in Farö, Iceland, and Greenland.

12,386. You are not under any obligations, are you, to the Governments of those countries to furnish them with any returns?—None whatever.

12,387. Will you be so good as to state to the Commission what are your duties with reference to observations?—They are entered in monthly schedules, which are returned to the office within a fortnight after the month is over. Those belonging to the eight large towns require to be sent to the office within four days, inasmuch as they are required by the Registrar-General for immediate use. The schedules are first examined, and if the barometric curves of the stations indicate discrepancies they are immediately inquired into. If it is a palpable clerical error of an inch of the barometer, which is not unfrequent, or if it is an error of half an inch, which is also about as frequent from the way in which barometers are graduated, I do not always communicate with the observer regarding it; but as regards the inversion in transcription of figures, for instance, 29·942, written for 29·249, which is also an occasional mistake, a communication with the observer is necessary. If there is an uncertainty about an observation at such a place as Farö, or Monach in the Western Hebrides, which are at great distances from other stations, suppose a suspected error of half an inch, if not cleared up by a correspondence with the observer it would not be altered, but it would be underlined, and a query entered in the margin. As regards the thermometer, we have maximum and minimum thermometers and wet and dry bulb thermometers in the shade all in the same box, the bulbs of the wet and dry thermometers and the minimum being at the same level, and the maximum a little higher. Supposing the maximum temperature be read on the 3rd of January, if we find the dry bulb at the moment of the observation or 12 hours before, to have exceeded the maximum, there is an error which must be cleared up, and the observer is communicated with. If, similarly, either of the dry bulbs be less than the minimum thermometer there is an error, and the observer is communicated with. With regard to the dry and wet bulbs, if the dry bulb be lower than the wet it may be a true observation, but the chances are that it is not a correct observation, and the observer is written to, and his attention drawn to it. We find from a number of our very best observers that it sometimes happens that the wet bulb may be one degree or even two degrees above the dry when there is a very rapid fall of temperature. This is, of course, due to the low conducting power of the water surrounding the wet bulb, which therefore does not fall so rapidly as the dry bulb. In such a case the observer not unfrequently notes it, and writes to that effect. Winds, rain, cloud, and other observations are carefully gone over, with the view of checking mistakes, thus involving a very heavy amount of work. It takes up fully one fourth of my time. When the examination for the detection of errors is completed, 55 out of the 90 schedules are taken to the Astronomer Royal for Scotland to be reduced by him for the use of the Registrar-General; the rest, about 50, are retained in the office and reduced by myself. Without these observations it would be impossible for the Registrar-General to make his reports complete,—they would be defective in an important practical respect. The index errors of the various instruments that are used are applied after summing up and averaging the columns. We permit none of the observers to apply the instrumental or index errors in making an observation, in order to prevent the occurrence of mistakes; the whole of these are applied at the foot of the column, as may be seen from the book schedules on the table. A note of all the index errors for each instrument at the various stations is kept in the office. In addition to the monthly schedules, the observers of the eight large towns send to the Registrar-General a weekly schedule of observations, the results of which are immediately published by him in the newspapers.

12,388. Does the Government pay in any shape for information supplied to the Registrar-General?—No. There is this advantage, however:—We have the benefit of the reductions made by the Astronomer Royal for the use of the Registrar-General; and we have the use of the type.

12,389. Are the 55 stations, the schedules from which are supplied to the Registrar-General, more important than the other 50 which are not supplied?—Not necessarily so; the first 55 were those which the society had at the time, and as the observers remove or die or are suspended, or in the event of a station going down, we select for the Registrar-General, subject to his approval, that station which best fills up any blank which may exist at the time, in order the better to represent the climate of Scotland.

12,390. The Registrar-General is not desirous, is he, that the number of schedules supplied to him should be increased?—The society made an application some time ago, of which the Registrar-General approved, to have an increase to these stations.

12,391. What was the result of that application?—The application was granted;—but afterwards it was withdrawn, because the Astronomer Royal required to have an addition made by the Treasury to his allowance for reducing the observations, of 68*l.*

12,392. Can you state to the Commission the precautions which the society has thought it necessary to take with a view to secure uniformity?—*First*, in respect of the hours of observation, these being 9 a.m. and 9 p.m.; *secondly*, in the amount of protection afforded to the thermometers, namely, by a box of a particular pattern in which they are placed; *thirdly*, in the method of reducing the observations, viz., in not using any corrections for range, on the ground that such corrections applicable to their stations have not yet been ascertained. This they have been enabled to carry out so far as temperature and moisture are concerned by the adoption of the two hours 9 a.m. and 9 p.m. at all their stations, those hours giving very nearly the mean of the day. As regards the other meteorological elements, such as corrections for pressure, we do not apply them, we wait till they have been ascertained and then they will be applied. *Fourthly*, in the height of the thermometers above ground, namely, four feet. This last point of conformity is regarded by the council as a vital condition in all temperature observations.

12,393. Have you reason to believe that your instructions are generally and carefully attended to?—Yes. I may mention, however, that, in the event of an old meteorological station being adopted, we have not invariably insisted upon uniform height or a particular box. If it is an old station and the observer is a good observer, we have rather allowed matters to remain as they were, and induced them to get another set of instruments and a box of the pattern we recommend, to compare them at least for some time before any change is effected.

12,394. Do you consider that anything in the way of occasional inspection would be either desirable or feasible?—That is exceedingly essential, but unfortunately our funds have been such that we cannot do it in the way in which it ought to be done. We consider that to do this effectually it would require about 60*l.* a year. The stations are very wide apart, and from the changes that occur, and from the accidents that are liable to happen to the instruments, the council consider it a very desirable thing. This, however, is occasionally done in lieu of the more satisfactory method of visitation. Suppose a period occurs of small barometric change for a week, the barometric observations at all the stations are reduced for each day during that week to sea level for the purpose of comparison, and in that way we ascertain what barometers are faulty. A few are faulty, and we would like to replace them if we were able to do so. With regard to the maximum and minimum

A. Buchan, Esq., F.R.S.E.

26 June 1872.

thermometers which are much used in determining mean temperature, the mean maximum and the mean minimum are similarly reduced, and the means of these taken and reduced to sea level and put down in charts, by means of which it is possible to detect any evaporation of the spirit in the minimum thermometers in stations which are virtually inaccessible to my visits in the meantime. In these cases the observer is written to, and his attention drawn to the faulty thermometer, and a printed form is sent instructing him how to put his thermometer right. In this way we endeavour, as far as we can, to make up for the want of that sufficient visitation which we think so very essential.

12,395. The society publishes a quarterly journal, does it not?—Yes.

12,396. Has it been published from the very beginning?—No; there first appeared what was called a quarterly report, containing from 12 to 32 pages in a smaller type, with no cover. In 1863 the society began to issue their Transactions in the form of the new series which is in the hands of the Commission.

12,397. Can you state generally the nature of the contents of the journal?—They may be classified under three heads:—First, the results of the observations at each station for each month, taken directly from the reductions in the schedules; secondly, notes of the weather of each month and a comparison of the results with the averages of previous years; and, thirdly, original papers on subjects connected with meteorology. Those original papers have been chiefly occupied with questions of Scotch meteorology, being discussions of the data collected by the society's observers; and it may be said that, taken together, they present a more complete account of the meteorology of Scotland than has been worked out for any other country. But questions of a wider import have been discussed in the papers, such as the temperature of the British Islands, with a chart of each month; also the temperature of the seas adjoining; the mean atmospheric pressure and the prevailing winds over the globe; storms and weather of Europe over certain periods and at certain times; storms which passed over the United States, North Atlantic, Europe, and Western Asia in March 1859; interruptions of temperature; solar radiation in relation to the crops; suggestions for increasing the supply of spring water at Malta; barometric gradients; weather and health, and prognostics. A great number of these are written by myself, under the direction of the council, who indicate to me what topic to take up and investigate, and during the investigation give assistance in various ways. I call upon the members of the council, showing them what has been done, so far as the ivestigation has gone, and get advice from them. These interviews often last three or four hours. The gentlemen who give most attention to this are Mr. Milne-Home, who, as chairman of the council, is the revising editor of the publication, and Mr. Thomas Stevenson, C.E., and Dr. Arthur Mitchell. The late Dr. Keith Johnston gave very great assistance in this matter. For agricultural subjects, Mr. Henry Stephens, author of "The Book of the Farm," has been my adviser. It is in that way that the papers are written. A considerable number of original papers are contributed by the members of the council themselves, who are working meteorologists, and a number of them pretty well known amongst meteorologists. They undertake investigations quite apart from mine. The Marquis of Tweeddale, the late Sir John Stuart Forbes, Mr. Milne-Home, the late Dr. Keith Johnston, Mr. Thomas Stevenson, the late Dr. Scoresby Jackson, Dr. Arthur Mitchell, Professor Wyville Thomson, Professor Crum Brown, Dr. James Stark, Professor Everett, Professor Core, Mr. Henry Stephens, Dr. Hjaltelin, Mr. A. O. Thorlacius of Iceland, Dr. Angus Smith, Sir Walter Elliot, Mr. E. J. Lowe, Mr. James Glaisher, Dr. Drewry Ottley, Dr. Moffatt of Hawarden, Mr. Arthur Forbes, the late Mr. D. A. Freeman, Captain Thomas, and Dr. W. T. Blackie, have severally contributed one or more papers. We have also received very valuable help from Professor Piazzi Smyth, Astronomer Royal for Scotland, who, in addition to the work of reducing the schedules, makes many most important calculations affecting the meteorology of Scotland as a whole, and comparisons of each month, with averages of the past. I may mention in connexion with this subject, that the society has given, from the very commencement of its operations, a very great deal of attention to observing the temperature of the sea. These observations were commenced in the beginning of 1857, on the suggestion of the late Professor Fleming, who was one of the most active members of the council. They have now been continued for 15 years, and it is generally acknowledged that they are the best sets of observations that we have upon the temperature of the Atlantic and adjoining seas. Nearly the whole of them have been made by men who went out in boats to a distance from the land. These observations on the temperature of the sea were commenced 10 or 12 years before any other systematic observations of the temperature of the North Atlantic were made in Europe. The members of council have done a great deal for the society, in the invention of new instruments for observation. Professor Fleming invented a rain gauge which is very widely used, and Mr. Thomas Stevenson and Sir Walter Elliot introduced certain improvements on rain gauges. Lord Tweeddale, in connexion with Mr. Peter Stevenson, an optician in Edinburgh, gave us a registering rain gauge for every 10 minutes, as well as a registering apparatus for barometric pressure and for the wet and dry bulb thermometers, also every 10 minutes. These recording instruments have been erected on his lordship's estate at Yester, and been in operation for the past four years. They have been designed with the view of illustrating the relation of solar radiation in connection with the growing crops. Mr. Thomas Stevenson, our honorary secretary, proposed the box for the protection of thermometers, which goes under the name of "Stevenson's box;" this box is now much used in Great Britain, and elsewhere. With this box we are enabled to secure very great uniformity in the observations at our different stations. Dr. Arthur Mitchell, convener of our Medico-Climatological Committee, invented an evapometer for ascertaining evaporation. Improved forms of Lind's anemometer; photometers; cloud-reflecting compasses, and a mode of ascertaining the temperature of falling rain, have been invented by Mr. Stevenson.

12,398. Has the value of your observations and of the publications of the society been acknowledged beyond the limits of Scotland?—Yes. As regards the estimation in which foreign meteorologists hold the society's publications, I may refer you to the society's memorial, which is in the hands of the Commission. [App. XIII.] We have had very many applications from societies for copies of our observations, especially those in Iceland, Faro, Shetland, Orkney, the Hebrides, and the west of Scotland. M. Le Verrier, when he had the charge of the observatory at Paris, and as President of the Scientific Association of France, has applied for them. To Dr. Buys Ballot, of Utrecht, we have sent regularly, for many years, the daily observations at five of our stations. Professor Mohn, of Christiania, Norway, has also received copies of the daily observations at seven stations, and, for the investigation of special storms, observations from many stations have been sent him. The Imperial Geographical Society of Russia have applied for pretty copious details with reference to certain storms and weather. The Meteorological Committee of the Board of Trade have also applied for, and been supplied with copies of these observations. With regard to the averages based upon the observations of many years, they are very much used; the Meteorological Committee of the Board of Trade use the barometric averages, as published by us in comparing the monthly means, for four out of their seven observatories, and they also use some of our averages for temperature.* The War Department of

---

* Quarterly Weather Report for 1869, p. 32; ditto 1870, p. 25.

A. Buchan, Esq., F.R.S.E.

26 June 1872.

the United States use our barometric charts, or that part of them referring to North America; Professor Wild, of St. Petersburgh, uses some of our averages for the Russian Empire; also Dr. Wojeikof, of the Imperial Geographical Society of St. Petersburgh, Dr. Buys Ballot, Utrecht; Dr. Jelinck, Vienna, and others might be added, but the above may be sufficient to show the important character of this part of the society's work, which, it is scarcely necessary to remark, could not have been so widely appreciated but for the broad scientific basis on which it has been placed, and the catholic spirit in which it has been worked out. Not a little of the society's work has been applied in furtherance of sanitary, agricultural, and other practical matters, just in the same way as other results of science have been similarly applied, and not, it is unnecessary to say, because the observations were originally designed for the elucidation of these objects. We frequently have applications from lawyers and parties interested in disputes with regard to perishable goods as to the weather which prevailed at a particular place at a particular time An account of such cases is given in the Journal, Vol. II., at page 282, and they will show the sort of information which is applied for and supplied by us in that way.

12,399. (*Dr. Sharpey.*) Have you to write out those statements in manuscript if application is made for them?—Yes; with an authentification that they are true copies.

12,400. Would you wish, had you the means, to publish the daily observations?—Yes; but that comes under the head of how we would spend the grant of money which we apply for. There are a number of ways in which the society has advanced meteorology. We have been quite unable to undertake many questions; but the Marquis of Tweeddale, the president, has very liberally come forward on five or six occasions, and given handsome sums of money for observations of such a nature as involve a good deal of work on the part of the observer. The most recent of these were on underground temperature, in connexion with agriculture and the temperature of the air. About eight observers were selected, who undertook to observe the barometer and all the instruments enumerated before, 16 times every day for four months,—the months being January, April, July, and October, as representative of the different seasons. Very valuable results were obtained with reference to the east wind, and with reference to radiation, solar and terrestrial; with reference to the cooling of the air and the cooling of the soil. A great deal yet awaits discussion. To the subject of ozone we have paid some attention, and Lord Tweeddale has again very liberally assisted us. Lord Tweeddale assisted the society also in giving prizes for essays on special subjects, such as the rainfall of Scotland, and some other matters bearing on Meteorology. As regards the information which has been collected in the society's office, a very great deal has been discussed; but very much still remains to be discussed, from the want of hands. There being no other paid official but myself, it has been impossible to do more than has been done.

12,401. (*Chairman.*) You have accumulated valuable materials, to a considerable extent, which you are not able to make use of?—Yes; and, as the Commission will see, every year adds to the value of those observations, especially as regards questions of averages. Each successive year, whilst it increases the value of the averages, greatly increases the laboriousness of the calculations, so that a discussion which could have been easily overtaken 10 years ago is now a formidable undertaking.

12,402. I believe that your work generally occupies a great many hours daily?—The necessary part of the office work takes from 10 to 12 hours a day; that time I gave to it till about three years ago, when my health broke down and I was unable to continue. There being no funds in the hands of the council to pay a clerk, I took the work upon myself and engaged a clerk to assist me for the past three years.

12,403. Has the work of the society been materially hindered from the want of sufficient funds?—We could have done a very great deal more than we have done, and I should have been stronger now than I am.

12,404. Will you state to the Commission generally what are the objects which you think would be more effectually carried out if you had more funds at your disposal?—Increased efficiency of the staff of the office; the work of visiting the stations could be adequately done; important papers could be published which cannot be done at present; and daily observations could be published, which the council would wish to do for 12 of our chief stations, so as to diffuse this information amongst meteorologists in different countries for general use. Additional sums are wanted for special investigations. I have a letter from Mr. Stevenson, our honorary secretary, in connexion with this matter, the substance of which I may state. It is an opinion pretty strongly held by members of the council that in working out the problems of meteorology the element of *time* is a very valuable element, which, of course, is well represented by self-recording apparatus; but the element of *space* is equally important and, perhaps, primarily goes before the other, inasmuch as those great atmospheric disturbances that we have to deal with are constantly changing,—being by no means uniform phenomena, but constantly altering in intensity and in the manner of their distribution. Hence, in order to attack successfully some of the great and urgent problems of meteorology, we require thickly-planted stations over limited districts, where we wish to investigage such points. To carry out this idea, Mr. Stevenson, some time ago, proposed to have a chain of barometers extending, say, in a southerly direction, at distances of about three miles apart, for the purpose of giving gradients;* that is to say, the barometric distances with the wind force as actually observed, in order to work out that great problem of meteorology, viz., the relation between these two phenomena, which is one of the greatest problems that meteorologists can attack. By erecting those stations and getting a chain of observers in different directions, we could contribute the data for the solution of this great question. From the constitution of our society and its management by a council of gentlemen, who take a personal interest in the society's work, we have the means of securing gratuitous services from observers. Another suggestion made by Mr. Stevenson is, that there should be several electrometers in Scotland. Electricity has such a very intimate relation to weather phenomena, that it is most desirable to have electrometers erected. The vapour of the atmosphere may be regarded as forming the great difficulty that the meteorologist has to deal with. The movements of the vapour of the atmosphere is revealed through the motions of the clouds. We have a number of observers who record on their schedules the amount of cloud, together with the direction and motion; but it is done in a rough way. What Mr. Stevenson suggests is, that at each station there should be cloud-reflecting compasses for marking accurately the direction of the motion of the clouds. I think that if the society were in a position to send instruments of this description to those of their observers who would take the trouble, very valuable information would be collected.

12,405. Are you acquainted with the operations carried on under the direction of the Meteorological Committee of the Royal Society?—Yes, I have read their publications.

12,406. Do they differ in any important respect from the work carried on by your society?—Their observations are continuous registration, ours are eye observations.

12,407. (*Sir J. P. Kay-Shuttleworth.*) What is the estimate which you have formed from the care that

---

* *Gradients*,—a term proposed by Mr. Stevenson in 1867, and now being generally adopted, by which the intensity of storms, or any aërial currents, may be expressed immediately by dividing the distance in miles between two barometric readings by the difference of these readings.

A. Buchan, Esq., F.R.S.E.

26 June 1872.

you have had to take in the reduction of the observations as to the competency of the persons who are generally occupied in making those observations throughout the country?—That they are very competent men; we have, on occasions, been obliged to draw the pen through single observations, but this is an extremely rare occurrence, and never but at one or two stations through a whole month's observations. The observer is of course communicated with, and the matter is either rectified, or we get quit of the observer.

12,408. In what class of life are the observers generally?—At present the class of life of the observers is as follows:—Country gentlemen who personally observe, 9; clergymen, 10; physicians, 12; schoolmasters, 13; gardeners, 28; farmers, 5; clerks, 4; professors, merchants, bankers, chemists, opticians, shoemakers, &c., 23.

12,409. Out of the whole number of observers in Scotland, which you stated to be about 90, what number, speaking roughly and generally, would you regard as not competent?—At present two;—the observations of one of these we do not in any way publish; those of the other are sometimes not published. This observer is, however, improving, particularly after a communication from the chairman of the council to his employer. In such cases, as the result of the correspondence that takes place, the quality of the observations improves, or the observer is struck off the list. Properly speaking, these persons, though they send in their observations, can scarcely be counted amongst the society's observers.

12,410. Are there any suggestions which you would be able to make, supposing that you had aid from the Government, which would in any degree increase the competency of the observers throughout Scotland?—If we had more funds we could complete the equipment of the instruments, and increase the number and improve the quality of the observations by the personal contact of the observers with the secretary during his visits. With regard to this matter, the society distributes free to each observer a copy of all its publications, and we find that this has the very best effect in awakening an interest in the subject. Take, for instance, the subject of thunder-storms, which was inquired into under the direction of the council about two or three years ago. Some very remarkable results were arrived at in the course of the inquiry, and suggestions were made that the observers should make the observations a little more complete, which had a very good effect. In the earlier years of the society, there was a good deal more of correspondence, the object of which was to make good observers; but now we have, excepting with new observers, but little to do in this way.

12,411. (*Dr. Sharpey.*) The operations of this society have the effect, have they not, of introducing instruction in meteorological observation into schools?—Yes; I understand that Mr. Milne-Home has some evidence to give upon that matter.

12,412. (*Professor Smith.*) You have contrasted the mode of observation adopted by the Scottish Meteorological Society and by the Meteorological Committee of the Board of Trade; I should like to know whether you consider both those methods of observation equally necessary for the advancement of meteorological science?—The observations of the Board of Trade Committee are not made on the same principle as those of our society, or of the English Meteorological Society. The most important of all meteorological instruments, viz., the thermometers, are at our stations and at the English stations kept, almost in all cases, at the uniform height of 4 feet above the ground, and at a distance from any buildings. The self-registering thermometers at the seven observatories of the Board of Trade Committee are attached to buildings and at heights varying from 4 to 41 feet above the ground. It is very obvious that the thermometric observations at our stations must, therefore, give results considerably different from those of the self-registering thermometers of the Board of Trade. Very useful conclusions may, no doubt, be drawn by means of self-registering thermometers, wherever placed, but when these differ from each other in height and exposure, they cannot supply the data by which the climates or atmospheric conditions of the districts in which they are kept can be compared with the same degree of accuracy which attaches to instruments that are at an uniform height above the ground and at a distance from buildings.

12,413. But would you wish to superadd to your present system of observation a few sparsely scattered observations of a self-registering kind?—Certainly we should; indeed the subject has been frequently before the council, but want of funds has hitherto prevented anything being done. What the council wished to see established was, at least two full-equipped observatories in Scotland. Such observatories should in my opinion contain the following instruments:—Self-registering barometers, dry and wet bulb thermometers, anemometers, and rain gauges. The height of the thermometers to be at the society's standard height of 4 feet above the ground, and the exposure and surroundings, so far as practicable, identical with that of the society's other stations, in order to obtain, among other data, thermometric and hygrometric CONSTANTS which would be applicable to the results obtained at our stations. Immediately adjoining these, but in an open situation over grass, there ought to be placed in the society's form of louvre-boarded box, maximum and minimum, and dry and wet bulb thermometers for the purpose of comparison. At the same stations there should also be placed the other instruments in use at the society's ordinary stations, viz., a freely-exposed rain gauge, a common H. C. anemometer, an evapometer, radiation thermometers, underground thermometers; and other instruments it has been proposed to add, viz., electrometers, cloud-reflecting compasses, an apparatus for ascertaining the temperature of falling rain, and photometers for ascertaining the variations of daylight. In addition to the above, such other instruments should be included as are suited for carrying on other physical researches which are allied to meteorology. These fully-equipped observatories are not intended to supersede the present stations of the society, but as supplements to them for the purpose of giving, by the continuous registrations, a complete representation of the important element of *time*, which is so desirable, and in some cases essential in conducting meteorological inquiries, the element of *space*, which, as already stated, is, perhaps, the more important of the two, being represented by the society's ordinary stations in the different parts of the country and islands adjoining.

12,414. (*Chairman.*) Are any of the stations under the direction of the Meteorological Committee situated in Scotland?—Yes, two of their observatories and seven of their telegraphic stations are. [*See* APPENDIX XIII.]

The witness withdrew.

D. Milne-Home, Esq., LL.D., F.R.S.E.

DAVID MILNE-HOME, of Wedderburn and Milne-Graden, Berwickshire, Esq., LL.D., F.R.S.E., &c. examined.

12,415. (*Chairman.*) Have you resided all your life in Scotland?—The greatest part of it.

12,416. You have always taken an interest, have you not, in physical research?—To a considerable extent.

12,417. And you have written on various scientific subjects?—I have, on several.

12,418. Are you a member of scientific societies, both in Scotland and England?—I am.

12,419. And the author of papers in their Transactions?—Yes.

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

12,420. Will you have the goodness to give the Commission information as to the way in which physical researches are aided in Scotland?—They are aided partly by individuals, partly by societies, and partly by the Universities.

12,421. Has a good deal been done by individuals in Scotland?—Of course I only speak within my own personal knowledge, but there are two or three cases which could be mentioned by me of individuals, friends of my own, who, having a taste for science, have spent large sums to promote it, or who, out of kindness to friends, have helped them in their investigations.

12,422. There are several scientific societies in Scotland, are there not?—Yes, in most of the large towns.

12,423. Are there any other associations having for their object the promotion of science?—There are a good many societies in the Scotch counties, called Field Clubs or Naturalists' Clubs. I attach much importance to those, and desire to bring under the attention of this Commission the valuable information which now is lost from the inability of these societies to publish Transactions. I have brought with me the last volume of the Transactions of one of these societies, a society to which I belong, in Berwickshire, as showing the sort of information which is got. They are devoted chiefly to natural history and archæology. That society, it so happens, is able to publish its Transactions; a good many landed proprietors in the neighbourhood being members of it. Accordingly they have some 30*l.* or 40*l.* a year of funds which enable them to publish Transactions. You will see from the volume the character of the papers written on different branches. There are 12 or 14 of those societies in Scotland, but there are only three or four able to publish Transactions; and, in consequence of that, an immense amount of valuable information is lost to the country. If these societies were aided either directly, or through the medium of some commission or board in Scotland, so that they might be enabled to publish Transactions, it would be of immense importance to the advancement of science, because many of the members of those societies are engaged in original research. I met a gentleman this forenoon, Mr. Jenner, brother of Sir William Jenner, who takes an interest in the Fife Natural History Society, and I asked him to-day whether he would be ready to give evidence with regard to his knowledge of the utility of those societies, if the Commission desired it, and he gave me his address, so that he might be sent for if the Commission wished it. I may mention that the working classes in Scotland, in consequence of the high education received at the parish schools, have acquired a taste for, and a considerable knowledge of, branches of natural history. I have brought up with me one of the school books used in the parochial schools, which shows the branches of natural history, the elements of which are taught in them. The lessons in these branches have been drawn up by Professors Tyndall, Balfour, Allman, and other men of reputation.

12,424. Do you know how much money the Berwickshire Naturalists' Club expend annually in the publication of their papers?—About 30*l.* or 40*l.* is the amount of their annual subscriptions, and most of it is applied to the printing of memoirs.

12,425. Do any other of the county clubs publish Transactions?—The Dumfries Club publishes its Transactions, and I think there is one in Perthshire which does the same, but I cannot name any other of my own knowledge. There are four or five altogether, I believe, out of the 12 which exist in Scotland. Besides those poor societies or clubs in the counties, there are a good many societies in the towns which are not able to publish Transactions except at long intervals. For example, the Geological Society of Edinburgh, which has presented a special memorial to the Commission, are only able to publish their Transactions from time to time, in consequence of the small amount of their income. Their members consist chiefly of artizans and of the working classes, who are exceedingly fond of geology and other branches of natural history, but who cannot afford to give more than 10*s.* or 12*s.* a year. So also in Glasgow there is a Geological Society, a Natural History Society, and an Archæological Society, each having small incomes from the necessity of keeping the annual subscriptions at a small amount, to suit the circumstances of their members. The researches made by the members of these societies are very valuable, but only one is able to publish Transactions, viz., the geological, after intervals, to allow of their funds gathering. If those societies were generally aided, science would be immensely benefitted. I suggested last year to the Royal Society of Edinburgh, that, in the event of any of those societies not being able to afford to publish Transactions, they might send their memoirs to the Royal Society to be published by the Royal Society either in the Royal Society's Proceedings, or in the Royal Society's Transactions, if they deserved such a place; but we found that we had not funds to enable us to do so. The Royal Society of Edinburgh is hardly able to afford to publish all the illustrations which are necessary for its own papers.

12,426. You think, on the whole, that a large amount of important information is lost from the want of sufficient means of publication?—I do.

12,427. Are there any branches of science in which the working and the middle classes of Scotland take special interest?—All branches of natural history—because these can be prosecuted without expense. Of course chemistry cannot be so prosecuted, and, therefore, I do not think they engage in it, but they take a great interest in entomology, archæology, botany, and geology. Some of the most valuable papers in the Edinburgh and Glasgow Geological Societies' Transactions have been written by men in the humblest walks of life, such as small tradesmen, grocers, bakers, joiners, and the like In country parts I know individuals of the working classes who have made important original researches in their own neighbourhood in botany, entomology, and geology. The late Sir Roderick Murchison placed the greatest reliance upon the information given to him by a baker in Thurso, a Mr. Dick.

12,428. Should you say, from your observations, that a larger amount of interest is taken in natural science amongst those classes in Scotland than elsewhere?—That, of course, I am not able to judge of, having been so much resident in Scotland, but from what I have heard there is not the same amount of scientific research amongst the working classes in England.

12,429. Have any of the larger societies in Scotland the means of encouraging original research?—The Royal Society of Edinburgh does a little, by prizes, and likewise by money grants for special objects; and the Highland and Agricultural Society is another society which, in that way, encourages original researches. By the Royal Society three prizes are given from money for the purpose, left by fellows of the society, namely, by Dr. Patrick Neill, Mr. Keith, who was the first secretary of the Royal Society, and the late Sir Thomas McDougal Brisbane. It has no medals or anything from the Government to assist it in that way. The Highland and Agricultural Society offers prizes to the amount of 300*l.* or 400*l.* a year, although they are not always claimed or awarded, for aiding the science of agriculture. There are separate prizes for fattening stock, and the encouragement of better tillage. The prizes for discoveries in the science of agriculture vary from 50*l.* down to 20*l.* and 10*l.*

12,430. Those prizes are offered from its yearly revenue?—Yes.

12,431. (*Dr. Sharpey.*) Those societies have no funds from which they can give assistance to any original inquirer who wished to undertake an investigation?—The Royal Society has been able from time to time to give a little. Sir Thomas McDougal Brisbane's most valuable magnetic and meteorological observations, made at an observatory on his own estate, were published partly by himself and partly by the Royal Society, at a cost of about 500*l.* or 600*l.* They form three volumes, quarto.

D. Milne-Home, Esq., LL.D., F.R.S.E.

6 June 1872.

12,432. What I referred to was aid to inquirers for conducting observations; there are no public means, are there, in Scotland, applicable to that purpose?—No, the only case that I know of was one in which I myself obtained, a year and a half ago, 10*l.*, to assist in discovering the position of remarkable boulders, with a view to ascertain how they were transported. The Society has also bought instruments from time to time for observations, such as barometers and thermometers, and an expensive anemometer on the Calton Hill.

12,433. (*Chairman.*) Have the prizes offered by the Royal Society and the Highland Society led to important results in many cases?—They have been the means of inducing original observations, and of having these published.

12,434. There is also a Society of Arts in Scotland?—Yes, a society for rewarding mechanical inventions. I must mention also (although, of course, I only speak of the Scottish societies) that the Royal Society of London has occasionally given help in Scotland to men of science out of the 1,000*l.* a year entrusted to it by the Government. The British Association has also, from time to time, given grants to men of science in Scotland for original researches.

12,435. The 1,000*l.* grant was placed at the disposal of the Royal Society of London for the whole United Kingdom, was it not?—It was.

12,436. Have you reason to believe that men of science in Scotland have often made applications to participate in the grant?—No, for the grant has not been sufficiently known in Scotland. Men of science in Scotland, generally, did not, till lately, know of its existence. One of those who shared in it, Dr. Gamgee, writes to Professor Balfour, the Secretary of the Royal Society of Edinburgh, in these terms:—"In 1866 the Royal Society of London gave me a grant of 50*l.* for the purchase of instruments for the investigation of many questions connected with the gases of the blood, and the action of poisons on blood. The results of my work were subsequently published in the Philosophical Transactions. I may mention, that I had no knowledge of the existence of the Government grant fund, and should not have applied for it, had not Professor Frankland written to me, and suggested the employment of instruments of considerable expense in the researches which I was carrying on at the time, adding that he felt sure the Royal Society Committee would be very happy to further such researches." Only three individuals in Scotland, so far as I know, have had a share in that grant during the 13 years of its existence. Those individuals are Dr. Gamgee, Sir William Thomson, and Professor Tait. Sir William Thomson is also a member of the Royal Society of London, and probably he knew of it in that way. Our Scotch Royal Society did not know anything of it, till I asked Professor Balfour to write to Dr. Sharpey, the secretary of the Royal Society of London, and he was so good as to make out a memorandum, intimating to us, what we did not know before, that this grant was really made for science in England, Scotland, and Ireland. This memorandum the Royal Society of Edinburgh printed in its proceedings, for the information of men of science in Scotland. I observe that the Royal Commissioners who sat upon the Irish societies likewise allude, in their Report, to the fact, that this grant was not known at all in Ireland.

12,437. (*Dr. Sharpey.*) The late Principal Forbes was a long time secretary to the Royal Society of Edinburgh, was he not?—He was.

12,438. And Sir David Brewster was president?—He was for a time.

12,439. I presume you are not aware that both those gentlemen were placed on the committee for distributing the Government grant of the Royal Society of London at its original formation? Then, of course, they individually must have known of its existence.

12,440. I think there have been two subsequent grants besides those that you refer to, one to Dr. Pettigrew, and another to Dr. Fraser, from the same fund?—Of this I was not aware. These must have been since the year 1866.

12,441. Could you suggest any way in which it could have been made more generally known?—Probably if a communication had been made to the Royal Society of Edinburgh, a notice of it would have been put into our Proceedings, and that would not only have made it known to all the fellows of our Society, but to men of science in Scotland generally.

12,442. I presume that you would recommend the same thing to be done with regard to other parts of the kingdom, Ireland for instance?—Yes, certainly.

12,443. (*Chairman.*) What is done by the Scottish Universities in the way of promoting original research?—Very little, for their chief duty is to teach, not to discover. But they have set apart, both in Glasgow and in Edinburgh, rooms or apartments for laboratories, where original researches are carried on by Sir William Thomson, Professor Tait, Professor Crum-Brown, and other persons who apply to them for permission. The University of Edinburgh also gives gold medals to medical students who, in their theses, point out new information bearing upon the subject of the thesis. Here is a letter from Sir Robert Christison, President of the Royal Society of Edinburgh, and one of the Professors in the University of Edinburgh, who describes some original researches conducted by Dr. Fraser, which I should like to be permitted to read:—"Dr. Fraser, who was for two years my class assistant, and during that time much engaged in toxicological researches of a practical and scientific nature, has been since, with my permission, constantly engaged in similar researches in my laboratory, though now an extra academical teacher. In the course of his earlier investigations, he investigated with great ability the properties of several new and remarkable poisons. More recently, he has been engaged in two sets of inquiries almost new." After describing what those are, he goes on to say:—"For some of these inquiries Dr. Fraser has been awarded one of the prizes of the Académie de Médécine at Paris, and for others the Bienniel Keith medal of our Royal Society. Such inquiries involve serious outlay both for materials, for instruments, and for accommodation. I have been able to aid him as to the last item, and partly in regard to the second, but still his outlay must be very large. Dr. Fraser has twice received a grant from the British Association. These particulars, in respect to a single case, will illustrate, better than a reference to any number of possible or supposed cases, how our Royal Society could with advantage administer grants in the direction of different branches of science. I have no doubt it is only the want of means which prevents many of our graduates of promise from carrying out similar researches, which, indeed, they often begin in their student days, but are obliged afterwards to abandon. I may mention, as another case in point, that I had myself long ago begun, and contemplated persevering with, an inquiry of an experimental nature into the physiological action of medicinal and poisonous plants; an inquiry purely scientific in its nature and its method, but no doubt fruitful in practical results for the improvement of medicine. But soon after I began, a rapid diminution of our students, through competition arising everywhere around, so reduced my income, that I had to abandon my favourite scheme, and betake myself to more promising means of winning my bread. At that time there was no public fund from which I could have been helped in what was certain to prove a very long and costly investigation. Nor is there any such fund yet in Scotland."

12,444. (*Dr. Sharpey.*) Sir Robert Christison seems not to be aware that Dr. Fraser recently obtained 50*l.* from the Government Grant Committee of the Royal Society of London for that very research that he refers to?—Yes, I think he alludes to it.

12,445. He speaks of the British Association?—Perhaps he is confusing the one with the other. He

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

says, "Dr. Fraser has twice received a grant from the British Association."

12,446. (*Chairman.*) Have you any recommendations to make as to what you consider might be done towards encouraging and assisting original research and observations in Scotland?—I think that great benefit would arise from assistance by a money grant, so that people might be enabled to carry on original researches. At present they cannot carry on any researches, except by spending their own funds, or getting help from some wealthy friend. In the advanced state of science, it is now impossible to make observations or experiments, of any value, except with instruments and other appliances far more costly than formerly.

12,447. Would you place such funds at the disposal of scientific societies?—Perhaps not in all cases. I should prefer to see a board, so that there should be some check, independent of those societies themselves, to bear the responsibility of the application of such grants.

12,448. Have you considered the constitution of such a board?—I cannot say I have formed a very definite opinion. Probably the Royal Society of Edinburgh might have a large share in the administration of it, being the oldest scientific society in Scotland, and a society which addresses itself to a great many branches of physical science; or there might be a combination of the Royal Society's Council and other parties, much in the same manner as the administrators of the Royal Society of London 1000*l.* grant, for, if I remember rightly, the Council of the Royal Society is combined with other persons.

12,449. I understand you to contemplate the establishment of a board solely for Scotland?—Yes, for Scotland solely.

12,450. Have you considered whether it would be practicable to establish a board which should have the whole of the United Kingdom under its control?—If a board existed in London, to administer a fund for Scotland, it would require to have the means of knowledge in Scotland through trustworthy individuals there.

12,451. Do you think that if provisions could be made for adequately representing Scotland and Ireland, one single board for the United Kingdom would not be preferable to boards for the separate portions of the kingdom?—I think that if the board were formed in England, with sub-committees in Ireland and Scotland, it might answer the purpose, but I do not see how it is possible that gentlemen in London, unconnected with Scotland, can have that knowledge which is desirable with regard to individuals applying for grants. If there were no board of that kind, the London Board would require to make inquiry through individuals selected by themselves, and who would not have the same responsibility as persons officially appointed.

12,452. (*Professor Stokes.*) Would not such inquiries, as a general rule, be carried on by correspondence by post?—I think a personal knowledge of the individual applying would be desirable.

12,453. But, even if there were a representative body for Scotland, they could not be supposed to be personally acquainted with every applicant or even the larger number?—The members of a Scotch Board might not be personally acquainted with every applicant, but they could obtain more full and more correct information, and could see the party applying, and form a better opinion by personal interview than by correspondence.

12,454. (*Dr. Sharpey.*) Would it answer to make those grants on recommendations from the Royal Society of Edinburgh? For instance, if an investigator desired aid, that he should have recourse to the Royal Society of Edinburgh, who would then give an opinion upon the expediency of allowing him a grant?—Yes, that is what I mean, that there ought to be a local board which should have the responsibility of administering, and, at all events, advising, after seeing the applicant or enquiring about him.

12,455. Should that advice go direct to the Government, or do you think that it might be submitted to a scientific council established in London, under the Government, for advising generally on the affairs of science?—I think that it would be a most desirable thing on all accounts, that there should be a scientific board in London to advise Government, and aid scientific inquiries over the whole kingdom. I couple with that, the desirableness of having committees in Ireland and Scotland who should be responsible to the country for the advice they gave, and that it should not be left to individuals who were unknown to the public, and who might be consulted merely upon the accident of being acquainted with persons in London.

12,456. Do not you think that the Royal Society of Edinburgh might very properly exercise the function of giving advice as regards Scotland?—Being a member of the Royal Society myself, and in the management of it, it is not for me to say that they are worthy of being so entrusted; but I have no doubt that if it were thought right, they would do their best to give advice in the matter. But it is proper to remember, that there are other societies in Scotland. The societies in Glasgow and Aberdeen might think that they should be consulted likewise; and what I would suggest would be, that the Royal Society's Council should be combined with one or two persons from other Scotch societies, who should be upon the board, although, perhaps, they might not always be able to attend personally, but with whom there would be the power of communicating.

12,457. (*Chairman.*) Are the fellows of the Royal Society of Edinburgh chiefly resident in Edinburgh, or does the Royal Society of Edinburgh include gentlemen from all parts of Scotland?—Two thirds of them are probably resident in Edinburgh, although there are others who join the society because they desire to promote the objects of science, and give their three guineas a year to assist in the funds, though unable to attend the meetings.

12,458. It is hardly representative of all the science in Scotland to the same extent that the Royal Society of London is of the science of England, and I might almost say of the United Kingdom?—According to the charter of the Royal Society of Edinburgh, it embraces all the physical sciences, literature, and archæology. In fact, it was the first society in Scotland which took up physical researches. I happen to have with me an address which, at the request of the Council, I delivered to the Royal Society of Edinburgh a few years ago, in which I give a list of the papers read during the previous year:—"The total "number of papers had been 44, all on physical sub-"jects. The following epitome shows the number of "the papers under each branch of science: mathe-"matical papers, 11; chemical, 7; mechanical or "natural philosophy papers, 6; medical, 4; geo-"logical, 3; zoological, 3; geographical, 2; botani-"cal, 1; meteorological, 1.

12,459. (*Dr. Sharpey.*) Formerly the society was more occupied, was it not, than it is now, with literary, historical, and philological research?—There was formerly a literary as well as a physical class. This division of the fellows into classes has been abolished. Some of the fellows still confine themselves to literature. For instance, one of our most distinguished fellows, Lord Neaves, addresses himself chiefly to literary and philological discussions, and Professor Blackie and two or three more give us occasionally a literary paper.

12,460. (*Chairman.*) Do you think that more encouragement to science is required in reference to schools?—There is no special encouragement just now given to science in parochial schools. The choice of the subjects depends upon the managers, that is, the heritors of parishes. But I may mention that a few years ago there was a society called the Agricultural Chemistry Association, which existed for some 8 or 10 years. The late Professor Johnston, of Durham, was its chief officer, and that association offered prizes to encourage the parochial schools to give instruction in agricultural chemistry. This is the little school book (*producing the same*) which was used for the purpose,

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

and it was introduced into about 70 parochial schools. The prizes were given wherever there was a class of scholars who showed proficiency in agricultural chemistry. That association was discontinued some years ago, so that probably these agricultural chemistry classes in schools no longer exist. We have been able also to encourage the teaching of meteorology in schools, because a great many of the parochial schoolmasters are observers for the Scotch Meteorological Society. They have instruments, and they use their instruments to give instruction in meteorology. The great want in Scotland, and I suppose in England also, is the non-existence of any regular fund to enable poor scholars to get forward to college. In my own county of Berwick I know two boys who showed considerable talent in the parish schools. They were the sons of labourers, and by means of private subscription they were enabled to go forward to Edinburgh College, but if there were a little fund, as in Germany, out of which money might be given to aid those poor scholars to go forward to the grammar school, or to a college, it would be a great encouragement to young lads, in all branches of knowledge.

12,461. (*Dr. Sharpey.*) Are there not a good many bursaries, certain annual sums awarded to poor students, particularly in Aberdeen and Glasgow?—Yes, but those are for students who have come up to the college, and who go up by examination, and are found deserving of rewards. What I mean is a provision to enable poor students to travel to Edinburgh, and be maintained there in lodgings whilst attending college.

12,462. (*Chairman.*) Are the regulations of the Science and Art Department pretty well known in Scotland?—They are not at all known, and I think it has been a great omission on the part of that Department not to make them known through the newspapers and otherwise. Mr. Buckmaster has come several times to our great towns to advocate the arrangements by the Kensington Department, and those meetings have been well attended, but the great want, in my opinion, as I told Mr. Buckmaster, was the want of sufficient advertisements in the newspapers, to make known to the parish schoolmasters and others the possibility of obtaining those grants. I believe, according to the regulations of that Department, there are sums of money which can be applied to enable poor students to get into the higher branches, but those are not sufficiently known.

12,463. (*Professor Smith.*) There are some of those examinations held in Scotland, are there not?—Yes; there are, I believe, about 30 or 40 schools in Scotland which have availed themselves of those grants from the South Kensington Department, but generally, throughout the country districts, there is no such thing known.

12,464. (*Chairman.*) At all events, you consider that a great want exists in Scotland of the means of enabling poor scholars to obtain the advantage of a superior education?—Yes, to go into a higher school.

12,465. Do you know whether there is more provision on the continent for cases of this kind?—I understand that in Germany there is a provision, so that a boy who distinguishes himself in the communal school is enabled to go to the college and to be advanced there. There is a fund for the purpose of paying his expense and giving him a small sum to enable him to live during the time that he is attending the classes, and he gets his education free.

12,466. You have stated that you consider it desirable that the State should assist the societies; can you point out in what manner you think such assistance could best be furnished?—I think that if a grant were given to well established societies, which are not able to publish Transactions, from insufficient income, those societies would be very much benefited. One practical difficulty is to judge whether or not it should be given to a particular society. I presume that those societies could not draw direct from the Treasury; that the Treasury would have to authorize some board which should have power to give, upon cause shown, the necessary aid to a particular society which desired to be aided, either on account of original researches by its members, or for the publication of Transactions, or to enable them to get respectable apartments for their meetings.

12,467. Does the Royal Society of Edinburgh receive at present any assistance from the State?—It receives a grant of 300*l.* a year, but that is merely to enable it to hold its sittings in apartments allotted to the Society. The rent paid for those rooms is 262*l.*, and they have to keep up the rooms, pay taxes, &c., so that the 300*l.* is, in fact, merely to enable them to have apartments to meet in. There is no other assistance that I know of which Government grants to any scientific society in Scotland. I believe that a sum of 300*l.* is paid annually on account of an archæological collection in Edinburgh, and from that sum the curators of the collection, the repairing of the cases, and the cleaning of the apartments are paid. That collection does not belong to the Society of Antiquaries. It belongs to the Government. To enable the society to carry on researches and explorations, and publish an account of these, it receives nothing from the Government. Moreover, the 300*l.* which is spent annually in maintaining the Government museum does not come from the Imperial purse, it comes from a Scotch purse;—for, at the time of the union between England and Scotland, there was a sum of 2,000*l.* a year which was appointed to be paid to compensate Scotland for certain duties which were imposed upon cotton and other articles of trade, and it is out of that 2,000*l.* a year that 300*l.* was taken to keep up this archæological collection.

12,468. The actual appropriation of the 2,000*l.* a year of which you speak, which was directed to be made by the Act of Union, was left open, was it not?—There was a board constituted at the time, the Board of Trustees for Arts and Manufactures, who had the disposal of this 2,000*l.* a year. A portion of this 2000*l.* is appropriated by these trustees, viz., about 1200*l.* to the maintenance of a picture gallery in Edinburgh. 300*l.* of it was taken by Mr. Wilson, of the Treasury, for the Archæological Museum. He thought that it was a very good application of a part of this 2,000*l.* a year, an application which was, however, very much objected to at the time by persons in Edinburgh, but unsuccessfully.

12,469. Is there not a public Botanic garden at Edinburgh?—Yes, there is a botanic garden which belongs to the Government, and the Professor of Botany is Regius Curator of the garden. I do not know how much is applied to maintain it. I think it is some 700*l.* or 800*l.* a year.

12,470. Is it open to the public?—It is.

12,471. Have you reason to believe that assistance is given in foreign countries to the promotion of scientific investigations to a much larger extent than in Great Britain?—I have no special information to enable me to state that, beyond what one sees from the public prints. From the statements made in the newspaper called "Nature," and other periodicals, it is very plain that in Germany, France, and the United States, the Executive Government gives very great assistance to scientific bodies and men of science to prosecute original researches. I would very respectfully suggest that the Commissioners should obtain correct information regarding the aid rendered by foreign Governments to aid in original researches, in matters of science.

12,472. Are you of opinion that more important discoveries are made elsewhere than in England?—Certainly, especially in Germany, in chemistry and agriculture.

12,473. You would hardly consider the agriculture of Germany to be in a more advanced state than the agriculture of Scotland?—I do not allude to the practice, but to the science of agriculture, of which we largely avail ourselves in this country. I need only refer to Liebig as our great leader in agricultural science. Many of our young men go to Germany to learn the principles of science in that and other branches of knowledge.

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

12,474. You have been many years a fellow of the Royal Society?—I have.

12,475. And you have contributed papers to its Transactions?—I have.

12,476. You have also acted as assistant secretary? —Yes, under Principal Forbes, when he was secretary; he was afterwards Principal of St. Andrew's.

12,477. The Royal Society of Edinburgh was founded in 1783, was it not?—It was.

12,478. What is the number of the fellows?—About 350 now.

12,479. Is that number stationary?—No, it has been increasing for some years past; 10 years ago there were about 300.

12,480. The society devotes itself, does it not, more to researches in science than to literature?—It does.

12,481. But literature is not altogether lost sight of?—By no means.

12,482. Is there any branch of science to which it has devoted more attention than others?—Geology is a branch of physical science which it took up keenly long ago, about the year 1808 or 1810, in the lifetime of Dr. Hutton, Lord Webb Seymour, Professor Jamieson, Sir James Hall, Sir George McKenzie, and Professor Playfair. It has ever since continued to take an interest in Geology, and never ceased to advocate the establishment of a separate Chair of Geology, until the late Sir Roderick Murchison, who was a fellow of the society, handsomely agreed to set apart 6,000*l.* for that purpose, which, with aid from Government, led to the endowment of the present Chair of Geology.

12,483. That professorship is in the University of Edinburgh?—Yes. There was always an intimate connexion between the Royal Society and the University of Edinburgh, insomuch that meetings of the Society were at first in the College, and the Museum belonging to the Royal Society was originally kept in the University, but latterly it has been kept in the society's apartments.

12,484. The society publishes both Proceedings and Transactions, does it not?—Yes.

12,485. Has it a difficulty, from the want of funds, in publishing to the extent which it would think desirable?—It has. On one occasion the illustrations of a paper would have cost 100*l.* if we had agreed to all that were desired, but we could not afford it, and the sum was cut down to 60*l.* Sometimes an author, rather than have his illustrations diminished, contributes a little from his own funds, if he is able, to aid the society in publishing the illustrations of his paper.

12,486. Has the society any endowment, or does it depend solely on the annual subscriptions of the fellows?—It depends entirely upon the subscriptions of the fellows and the money that has been sunk by the redemption of subscriptions. It has 700*l.* a year from those annual subscriptions, about 300*l.* a year from the redemption of subscriptions, and 300*l.* from the Government grant. I do not, of course, speak of prizes, because the prizes form no part of its ordinary expenditure.

12,487. It has no surplus revenue to meet occasional expenses?—We generally try to save 100*l.* or 150*l.* a year, so that we might be able to aid in any special object; for example, when the British Association came to Edinburgh last year, we gave 100*l.* to the fund which was raised to pay expenses. We have a library and a museum. We fitted up the rooms, and we paid the expense of providing bookcases and cabinets. Government did not assist us in the fittings to any extent.

12,488. Is the museum of much importance?—Not at all. It chiefly consists of specimens that have been brought to the society in illustration of particular papers. There are two or three collections of interest historically, as for example, the Huttonian collection which was made at the time of the celebrated controversy between the Wernerians and Huttonians. There is a valuable collection of fishes by the late Dr. Parnell, and a collection of fossils by Ure of Rutherglen.

12,489. The Government grant of 300*l.* a year commenced, did it not, in the year 1836?—Yes.

12,490. Was it for any specific object?—Not having been a member of the council at that time, I do not know, but I believe it was to enable it to pay the rent of the apartments, and other expenses connected with the repairing and cleaning of the apartments. The exact sum which we pay as rent is 260*l.*, which is for three small apartments.

12,491. Were they more inadequately lodged previously to that grant, do you know?—I do not remember. I was not a fellow at that time, and they have been in the present apartments ever since I became a fellow.

12,492. Is a larger grant in your opinion very desirable?—I think so, and it is the opinion of the council. They have presented a memorial which, I presume, the Commission have received.

12,493. In what respects do you feel yourselves cramped for want of sufficient funds?—We are not always able to publish, in full, the papers and necessary illustrations as we should like to do; and we should wish also to be able to aid the fellows of the society in carrying on original researches. Our accommodation for the society's meetings is of a poor and shabby character. The room in which we meet for tea after the ordinary business of the society, has no furniture in it; there is no chair or sofa in it. Also, with regard to diagrams on a large scale that are exhibited in illustration of the papers read, the author who shows them has himself to pay for the construction of them. Most societies, for the sake of having proper illustrations to induce public interest in those subjects, can afford to make those diagrams. But we have no fund for the purpose.

12,494. Would you think it desirable that you should be enabled to assist provincial societies?—That was a suggestion which was made by me two years ago to the Council, but we have no funds to enable us to do so.

12,495. Are you of opinion that a good many valuable papers that are read before the Royal Society, itself, are not published for want of sufficient means? —No, I cannot say that, but they have frequently to be curtailed, and the illustrations cut down.

12,496. Have you thought in your own mind how much would enable the society to carry out those objects?—There might be one sum desirable one year and another sum another year; there is no specific sum which one can fix upon, but 500*l.* a year is the sum which we think we can very usefully apply in aid, not only of our own fellows, but of men of science in Scotland.

12,497. This would be applied, would it not, partly for objects directly connected with the society, and partly for objects akin to those that are provided for by the Government grant of 1,000*l.* to the Royal Society of London?—Yes.

12,498. Do you think it very desirable that the Royal Society of Edinburgh should have at its disposal a certain sum of that kind?—Yes.

12,499. Would you rather have that, than see the Government grant here increased with full liberty to Scotland to participate in it to any extent that they might make out a claim?—If proper arrangements were made for a fair share of it being applicable to Scotland, and facilities given to men of science in Scotland to share in it, it might be satisfactory; but we certainly are anxious to get also a grant to enable us to carry on our own operations more successfully. There is one condition on which the Royal Society of London administer their 1000*l.* grant, which I entirely approve of, viz., that it shall not be for time, but merely for outlay in the purchase of instruments, or in employing computers.

12,500. (*Dr. Sharpey.*) It is not applied to defray the personal expenses of the inquirers themselves, but it may happen that in an inquiry which they originated, they might wish the aid of an assistant, and that may be allowed for?—Just so. I omitted to state that the late Principal Forbes once or twice got the sum of 15*l.*

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

from the Royal Society of Edinburgh to enable him to engage a computer, and I think Professor Tait, at this moment, has a grant from the British Association to employ a computer.

12,501. (*Chairman.*) I believe you are Chairman of the Council of the Meteorological Society?—I am.

12,502. And Lord Tweeddale is President?—Yes. I think there is a statement before the Commissioners from the Society. [*See* APPENDIX XIII.]

12,503. The establishment of this society was promoted, was it not, by the Highland and Agricultural Society originally?—It was encouraged by them.

12,504. Do they give any encouragement to it?—They gave us the use of their hall for our meetings, and a yearly subscription, which is now 20*l.* They also said they would encourage their members, the landed proprietors of Scotland, to support the society, that is to say, to get instruments, and to induce their factors, tenants, and gardeners to aid in the work of observation.

12,505. Can you explain the circumstances under which, although the number of stations is about 90, the returns from 55 only go to the Registrar General of Scotland?—The reason of that was, that when we applied to the Government originally to give us assistance, the stations belonging to the society were 55 in number, and the Treasury, after communicating with the Registrar General and likewise with the Board of Trade, entered into an arrangement by which the observations made at all our stations should be reduced. An arrangement was made between the Treasury and the Astronomer Royal in Scotland, that he should reduce the observations for a salary to him and his assistant of 150*l.* I may also add that a year or two afterwards, namely, in 1867, there was an application made by the Scotch Registrar General and the society jointly, to the Treasury, pointing out that those 55 stations did not comprehend the whole of Scotland, but that the society had now stations in many other parts of the country; and it was proposed that 17 more stations should be given to the Registrar General, that his information regarding the weather and climate of the different districts of the country might be more correct. Some communication took place between the Treasury and the Astronomer Royal, and the Astronomer Royal said that he would require 68*l.* of additional salary to enable him to do it, because it would require more staff assistance, new books, and larger sheets of paper, for tables of reduction, &c. The Treasury, however, declined to pay this additional charge; and hence the Registrar General of Scotland is still supplied with observations from only 55 stations, whilst there are several districts of Scotland from which he gets no information, though the society has stations in those districts. If the Commissioners would look into any of the annual reports of the Scotch Registrar General, they will see the important connection which subsists between the diseases and mortality of different districts, and the climate and weather of those districts, as shown by the returns obtained at our stations. I happen to have here the Report by the Scotch Registrar General for the year 1871. In that report, consisting of 35 pages, the last ten are occupied by a chapter, headed, "*Weather, and its Influence on the Mortality.*" In that chapter the Registrar states, that "In Scotland there are various "circumstances which give special facilities for "tracing the connection between certain meteorological "phenomena and the prevalence of disease;" and "among these circumstances," he specifies "the "nature and extent of the observations at meteorological stations, which have furnished trustworthy "means for comparing the monthly means of any "year with the corresponding means of ten years' "observations." He then gives an instructive table for every month of the year 1871, "showing the "connection between certain atmospheric phenomena, "and the deaths from certain diseases and classes of "diseases in the eight principal towns of Scotland." The report is full of important explanations, founded on the varying conditions of the atmosphere in Scotland; and the only matter of regret is, that the area of observation, on which these explanations are founded, is limited in extent by not embracing the whole of Scotland, when, for the small yearly sum of 70*l.*, to be added to the allowance of 150*l.* paid to the Astronomer Royal, the area could be extended so as to embrace the whole of Scotland. The Council of the Meteorological Society were of opinion that the sum of 68*l.* asked by the Astronomer Royal for doing the additional work proposed, was a fair and reasonable charge, and they wrote to the Treasury stating this to be their opinion, and their grounds for doing so; but the Treasury refused to sanction the additional expense.

12,506. Have the results obtained by the Meteorological Society been of importance, with reference to agriculture?—Indirectly they have. For example, wheat cannot be grown in certain parts of Scotland, on account of insufficient heat. The limits have been well ascertained by our observations.

12,507. Do you know of any instances in which the growth of wheat has been discontinued in consequence of the result of those observations?—No, I do not. Of course we give warning, by means of our publications, to people not to attempt it. Probably our chief work, in connection with agriculture, is to explain or to discover the reasons of the existing practice. For example, if we wish to know why the dairy system exists upon the west of Scotland and not upon the east, the immense amount of rainfall which occurs upon the west of Scotland sufficiently explains the difference; and why wheat prevails chiefly on the east part of the country in consequence of the less rain, greater heat, and greater dryness of the climate.

12,508. You have made some observations, have you not, as to the influence of hills and forests on the amount of rainfall?—The subject of forests is a subject that I have paid some attention to myself. I wrote a paper about it, which had the effect of inducing the Government of the Island of Malta to pass a decree, setting aside 900*l.* a year for 10 years, in order to cover the island with forests, in the hope of getting a greater amount of rainfall.

12,509. Has that experiment only recently commenced?—The planting of the island was commenced about 18 months ago. There has been, and there can be no result as yet. It is well known that there is a law to that effect in the South of France and likewise in Italy, that when so much forest is cut down there must be so much planted again. In many parts of France the rainfall is so great and sudden that it carries off the soil to a large extent. The floods in the rivers are also so great as to injure the manufacturers. It was found that forests reduce and regulate the amount of floods in the rivers.

12,510. Has the society obtained any important results bearing upon navigation?—Only by explaining the principles upon which storms traverse the surface of the earth, the way in which they are generated, and the mode in which the wind veers in those storms. The object of the society is twofold, partly local—that is, partly to ascertain what is peculiar to Scotland, and partly of a more general character, so as to assist other scientific bodies endeavouring to ascertain the laws which regulate the changes in the currents of the atmosphere. Our secretary has paid great attention to the subject of storms, and two of his papers have been published in the Transactions of the Royal Society of Edinburgh.

12,511. Do you furnish from time to time information to various public bodies? Yes.

12,512. Are you obliged to refuse applications from want of a sufficient staff?—Yes. I have a letter from the late Admiral FitzRoy, in which he alludes to the information which he got from us for the Admiralty on one occasion. There have been several applications made to us from the Board of Trade Committee for returns, and a great many applications from foreign Governments, some of which we endeavour to meet, but others we cannot from want of a sufficient staff. Mr. Buchan works as almost no other officer in his

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

position would have worked, and the consequence has been that his health gave way under it. It is only his enthusiastic fondness for the duties and his attachment to the society which induced him to undertake the work he has done. The only assistance he has had, has been from a niece, a young lady who is fond of meteorology, and who gives some gratuitous assistance.

12,513. Has it been one object of the society to encourage instruction in meteorology in schools?—Not specially, but indirectly. A number of schools have taken up the subject of meteorology, chiefly from the fact of a great many schoolmasters being our observers. We made some specific communication to the normal schools of the Established Church and the Free Church, in order to have young teachers trained in those institutions, to teach meteorology in the schools to which they should be appointed. In some academies, for instance, in the Dollar Academy, where young men are prepared for the army, and for foreign life, they receive meteorological instruction. The Dollar Academy is one of our stations. Also, in the Elgin and the Inverness Academies instruction in meteorology is given, but it is only by recommending them, or endeavouring to persuade them to do it; we have no special fund for the sake of giving prizes, as we might do if we had the funds. No doubt great encouragement would be given by prizes to students who passed a good examination in the science. Just as in the case of agricultural chemistry, a few shillings bestowed in prizes enabled the Agricultural Chemistry Association, as I said before, to have agricultural chemistry taught in no less than 70 parish schools; if we had a few shillings, in the same way, to bestow upon schools where meteorology was taught, it would be a very great assistance.

12,514. Are you acquainted with any instances in other countries in which instruction in meteorology is provided in the schools?—I had occasion some years ago to study the system of school instruction in Canada, and I know that in Canada there were then 12 grammar schools supplied by the Government with instruments, upon the condition that the teachers sent reports of observations to the Central Education Board. I know also that in France, in some of the superior schools, the Government supplies instruments with the same object.

12,515. Is your society in communication with any foreign meteorological department?—Merely by correspondence. A number of them send printed observations to us, and in the hope, of course, that we send to them our printed observations in return. We send what we publish, which, however, are only monthly averages. The Registrar General finds monthly averages enough for his purpose. But the foreign tables which come to us contain the actual observations made daily at the stations, and which are made in some countries twice daily, in other countries thrice daily. Foreign Governments print all these observations. We feel great regret, and a certain amount of shame, at not being able to send printed returns of our daily observations. Mr. Buchan is obliged, when he sends any daily observations, to copy them and send them in manuscript, which takes up much time on the part of himself and the young lady who assists him. These daily printed returns come to us from Austria, Russia, Sweden, Italy, Denmark, Norway, and Switzerland.

12,516. If you had the means you would think it desirable to print and publish your daily observations?—Perhaps not from all our stations, but only from such as might be in eligible districts.

12,517. When your society was first started, what encouragement did it receive from the Board of Trade?—About the year 1857 we began to fear that, unless we had some Government support, the society would go down, and accordingly we applied to the Treasury, and the Treasury then applied to Admiral FitRoy for his opinion. I have here a letter from Admiral FitzRoy, and another from the Registrar General of Scotland. I may read, perhaps, the Registrar General's letter, dated May 18th, 1858:—"I "am desirous of bringing under the consideration of "the Lords Commissioners of Her Majesty's Treasury the enclosed copy of a communication which "I have received from the Meteorological Association "of Scotland, from which it will appear that I am "likely to be deprived of the information on meteorological subjects which I have hitherto received through "the instrumentality of that body. I need not point "out to their Lordships the important bearing which "such information has on medical statistics, and I "feel persuaded that if I can no longer obtain it, the "quarterly and monthly reports which are issued from "this office will lose much of their value. When the "General Registry Office, &c., was first established, "the Meteorological Society of Scotland was not in "existence, but a few private observers who were in "communication with the Meteorological Society of "England, and some other gentlemen who take an "interest in such matters, agreed to send me their "returns, which I published in the same way as is "done by the Registrar-General of England. Since "the establishment of the society, the observations "have been greatly extended, the instruments supplied are more fit for the purpose of securing accurate results, and I feel that the value of my reports "has been greatly enhanced by the assistance which "the society has afforded me. It is, therefore, with "great regret that I have received information of the "prospect which exists of the dissolution of the society "at an early period, for I know of no other source "through which I can procure the returns in question. "I am quite aware of the objections which exist to "making grants of public money in aid of the funds "of private societies, but I wish, with all deference, "to ask their Lordships whether there exists the same "objection to my paying, as a public officer, for information and returns which I obtain through private "instrumentality. If I may be allowed to do this, the "rate, of course, being fixed with their Lordships' sanction, I believe the existing difficulty may be overcome."

"The Registrar General (Scotland) to H. Waddington,
"Esq., Home Office, London.
"16th June 1858.

"I ENCLOSE, for the information of Mr. Secretary "Walpole, a copy of a letter which I wrote to the "Lords Commissioners of the Treasury, on the subject "to which you refer in your letter of the 15th inst., "enclosing the memorials of the Meteorological "Society of England. From my letter to the Secretary to the Treasury, Mr. Walpole will perceive that "I attach great value to the possession of the returns "in question, and if the society is dissolved, I am at a "loss to say where I am to turn in order to procure "the information which I at present derive through "its instrumentality. I have only to add that the "character and scientific requirements of the gentlemen who take the chief management of the business "of the Meteorological Society afford a satisfactory "guarantee that the returns will be accurate and "trustworthy.

"(Signed) W. P. DUNDAS."

At that time Admiral FitzRoy proposed that the Treasury should give us an allowance according to the amount of our subscriptions, but the Treasury saw difficulties in the way of that recommendation, instead of which they agreed to supply us with instruments, and likewise they agreed that the observations at all our stations should be handed to the Astronomer Royal for Scotland, and that we should be saved the expense of reduction, and likewise that we should have the use of the types of those reductions if we wished to print them in our journal. One of the inducements to our subscribers is, that they are supplied with gratuitous copies of the journal, and likewise that they shall have their instruments verified and the stations visited.

12,518. The instruments were, in fact, only supplied, I believe, in a few instances?—We had, I think, 12 or 14 sets of instruments sent to us by the Board of Trade.

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

12,519. Are additions ever made, from time to time, to the number of sets of instruments supplied by the Government?—No. I am sorry to say that our applications to the Government during the last few years have not been encouraging. During Admiral FitzRoy's time we once or twice did apply to the Government, and they aided us with instruments for the Hebrides and Iceland, and likewise for Palestine. We were very much urged to have certain stations formed in the Mediterranean. The Government then were more liberal, and they aided us.

12,520. You applied to the Government, did you not, to provide you with apartments?—Yes, we did.

12,521. And, to a certain extent, with success?—Yes. The General Post Office in Edinburgh was constructed not merely for the service of the post office, but likewise to provide certain semi-official public bodies with accommodation; for example, the Ordnance Survey, Lunacy Board, and Commander-in-Chief's office. So we, at the same time, represented to the Government that we were supplying an important Government department with information, and that the Government had so far recognized us by giving us sets of instruments, and making arrangements with the Astronomer Royal by which our observations should be reduced, and we hoped that the Government would, therefore, set apart to us a portion of this building, which, accordingly, they did, and gave us the use of three small rooms in the uppermost flat of the building. They exacted, however, from us a rent of 30*l.* for the use of those rooms, and, at the same time, made us pay a share of the cleaning department of the whole establishment of the post office, viz., 7*l.* or 8*l.* We pleaded to be relieved of rent, but with no success, and we were obliged to submit. We were also greatly mortified at the refusal of the Government to give to the Registrar General some additional stations, as we should have been thereby in some degree helped, without putting much additional expense upon the Government, by relieving our secretary of some reduction work, and by our obtaining the use of the types set up for the Government. That is what I think ought to be done now. For the sake of making the Registrar General's information accurate and complete, he should take the observations from all, or most of our stations, and then when the types are up, we might have the use of them. That would relieve our over-worked secretary of a considerable portion of the mechanical drudgery that falls upon him now.

12,522. Does the Registrar General think it desirable that the returns should be sent to him from all your stations?—Certainly, he thinks that there ought to be an addition made to the 55 which were given to him in the year 1858. His information, at present, is incomplete, and our society is ready to supply it; but the Treasury refuses to pay the Astronomer Royal of Scotland the paltry additional sum which is necessary.

12,523. Is it your own opinion that the 55 should be somewhat increased?—I think they certainly ought to be increased, because there are a great many parts, the north-west particularly of Scotland, from which the Registrar General gets no information just now of a meteorological character, although his tables of sickness and mortality include those districts.

12,524. Do you require assistance from the Government in any other respects?—We think that the salary of our secretary, which is from 180*l.* to 190*l.* (for it varies with the subscriptions), is a great deal too small for the work which he does. We think that he ought to have the assistance of a clerk to enable him to do the arithmetical drudgery, the mere summing and averaging of multitudes of figures. Another very important work which we have not the means of doing is to enable the secretary to visit stations, because many of our observers are persons in a humble rank of life, who, though animated by a desire to serve us, have not, without instructions, that knowledge which is necessary for observation, and, therefore, we are anxious both that the observers and the instruments should be frequently visited by our secretary. We have no means of doing that at present.

12,525. In your application to the Government, was a definite sum ever named as required by the society?—I think 300*l.* was suggested.

12,526. Do you think that that would enable you to do your work satisfactorily in all respects?—Yes, I think so. It would enable us to give a proper addition to the salary of Mr. Buchan, to engage an assistant for him, pay travelling to stations, purchase instruments, and carry on special observations and enquiries.

12,527. Did you have a distinct refusal to that application from the Government?—No; what the Government said was:—Parliament gives 10,000*l.* a year for meteorological observations, not merely in England, but all over Great Britain, and as your work is in Scotland we hold (that was the language of the Treasury) that this 10,000*l.* a year is intended for Scotland just as much as for any other part of Great Britain, and, therefore, it will be legitimate for the Committee of the Board of Trade to apply a portion of that 10,000*l.* a year to aid you in your work. We went on this hint to the Board of Trade Committee, and they did not deny the interpretation so put upon the terms of the grant; nor did they deny that the Scottish society was doing important and indispensable work for the Government and the interests of science; but they said:—We have quite enough to do already with the grant; in fact it is too little for the work we are carrying on, and we want to do other things besides, but we cannot, in consequence of the 10,000*l.* not being sufficient. But they added that there ought to be a separate grant for us as a society. General Sir Edward Sabine several times said to me the same thing, and promised if the Government applied to him for his advice, he would distinctly give an opinion to that effect; and so between the two parties, viz., the Treasury on the one hand, and the Board of Trade Committee on the other, we have never got anything. At the last deputation that went to the Treasury, the Chancellor of the Exchequer received us, and said he thought the people of Scotland were so exceedingly liberal and generous towards us, that we had only to apply again. On the occasion of this interview, our Council was accompanied by about 20 Scotch members of Parliament. Colonel Sykes was our spokesman, and the point that he pressed was, that if the Treasury refused to give to the Scotch society a separate grant, it should require the Board of Trade Committee to set apart, out of its 10,000*l.* a year, an annual grant of 300*l.* for the Scotch society. The answer that the Chancellor of the Exchequer made was this (as published in the newspapers):—"What you tell me of " your proceedings is most honourable to you. It is " not from any wish to do anything otherwise than " agreeable to you, that I refuse your application; " but it is absolutely necessary, if public economy is " to be maintained, that I must decline to accede to " your wishes. You quote several instances in sup- " port of your case. I cannot say that your instances " are very wide of the mark. It is difficult to dis- " criminate. But I am, on principle, opposed to all " these grants, and would like to see them stopped. " The first maxim of economy is, that Government " should never do for people what they can do for " themselves. I hold it is our duty not to spend " the public money for that which the people can do " for themselves. You are an excellent society, and " if the people of Scotland cannot support you, let the " whole thing stop till the loss is felt." The Board of Trade had upon a former occasion insisted upon the committee allocating a part of the 10,000*l.* a year to storm signals, which they had uniformly refused before. The people of Scotland made a great noise about that in conjunction with applications from Liverpool and other seaport towns. The Scotch Meteorological Society brought the matter before the British Association at its Dundee meeting in 1868, and got a resolution passed to memorialize the Treasury on the subject. The Treasury listened to these applications, and specially required the Board of Trade Committee to provide the storm signals out of the Parliamentary grant of 10,000*l.*, and the committee at length agreed to do so, at a cost of probably more than 1,000*l.* yearly. We quoted that precedent to show that the Treasury might exercise control over the administration of the grant, and we asked the Treasury to do so, in our behalf, if they thought we deserved it. Mr. Lowe's answer to us, therefore, was entirely irrelevant, when he said :—" It is absolutely necessary, if public " economy is to be maintained, that I must decline " your wishes." And the next remark he made was, " that Government should never do for people " what they can do for themselves. I hold it is my " duty not to spend the public money for that which " the people can do for themselves." We were not asking anything for ourselves ; what we were asking was to enable us to do work for the Government and for the country, which we considered we were doing by supplying the Registrar General with information which he could not get in any other way, and also by promoting the interests of general science. However, we acquiesced in the refusal of the Government, and resolved to take the course which Mr. Lowe had suggested, of again appealing to the Scotch public for more subscriptions. We issued about a thousand circulars, asking for increased subscriptions and additional members. The result was that we succeeded in increasing the income of the society only by 15*l.* yearly. I believe that the public in Scotland thought that they had done quite enough, and that the Government ought to assist. Our Society then determined to bring the matter before the House of Commons ; but Dr. Lyon Playfair, Colonel Sykes, and a good many others of our friends urged us not to do so, seeing that this Commission had been appointed, and it was suggested to us that Parliament probably would not interfere as long as this Commission lasted, and that it was far better for us to put the thing into the hands of this Commission, and accordingly we have submitted our statement to you by that paper which has been forwarded to you. [*See* APPENDIX XIII.]

12,528. Perhaps, it will be convenient that we should have distinctly on record the grounds upon which the society rests its claim to a grant ?—The ground on which the society rests its claims for a grant are, first, that it is a society which, by its original and very numerous observations at about 100 stations, is doing much to help in the discovery of the general laws which regulate movements and changes in the earth's atmosphere. Secondly, that it addresses itself to questions having an important bearing on great public interests, such as the health of the people, agriculture, navigation, &c. Thirdly, that it aids, by the information gratuitously given, public departments, such as the Registrar-General, Admiralty, Board of Trade, and national schools.

12,529. Have you considered what expense the Government would be put to, supposing they had not your society to resort to, if they were desirous to obtain the information which they now procure through your society for the Registrar-General, the Admiralty, and the Board of Trade ; would it actually cost them a considerable sum to obtain that information ?—I should think so. It is most likely that those parties who are working for us, for nothing, would not work for the Government for nothing ; that is to say, farmers, factors, gardeners, parochial schoolmasters, and so on. We are exercising an influence through the landed proprietors in the country. The Duke of Buccleuch, for example, has established six stations. He provided the instruments, and got his factors and farmers and other people under him to establish those stations for us. It would not be possible for the Government to get such a number of stations throughout the country as we have, except through the means of such an association as ours, which has influenced landed proprietors and others promoting it.

12,530. Are there any points connected with the Highland and Agricultural Society of Scotland which you would like to bring before the Commission ?—I happen to be a Director of the Highland Society, and they requested me to lay a memorial before the Commission, and especially to make known to the Commission what is now being done in Germany to promote the science of agriculture. This is the memorial which they asked me to present to you :—

" To the Royal Commissioners on Scientific Instruction and the Advancement of Science.

" The Memorial of the Highland and Agricultural Society of Scotland, incorporated by Royal Charter,

" Showeth,

" That the society represents upwards of 4,000 of the principal proprietors, tenants, farmers, and scientific men in Scotland ; that one of the objects for which the said society was founded is the advancement of the science of agriculture, with which view the society has, by means of prizes and money grants, endeavoured to encourage observations, experiments, and discoveries in other sciences connected with agriculture, such as chemistry, botany, geology, meteorology, and arboriculture ; that the society has lately been inquiring into the system pursued in Germany for advancing the science of agriculture by means of experimental stations, where trials are made of new kinds of grasses, grain, and green crops, and also of the effect of the new artificial manures on soils of different qualities ; that these stations consist of a few acres of ground and suitable offices attached, managed by a scientific superintendent and others, to assist him ; that your memorialists much desire to see stations of the same kind formed in Scotland, being satisfied that observations and conclusions can be satisfactory, only when the result of scientific care and precision ; that the society strongly urge on the Government the expediency of establishing one or more of these stations in Scotland, or of advancing scientific research in any other manner which may appear to the Commissioners to be more conducive to the progress of agriculture ; that in the arrangement of any scheme the Commissioners may recommend to Her Majesty's Government, the Society will be glad to aid by giving all the information they have collected on the subject ; and your memorialists will pray. Signed in the name and by the authority of the Highland and Agricultural Society of Scotland.

" JAMES E. NEWTON,
" Chairman."

I may mention that, for some years past, the Society has endeavoured to promote discoveries in the science of agriculture through the farmers. They thought they might be able to do it economically in that way, by securing the gratuitous services of intelligent men. But I am sorry to say, that there have not been such results as can be useful for the advancement of science. I have here a letter from one of the most intelligent farmers in Scotland, who had been entrusted with experiments upon his farm. In consequence of the disappointment that he has met in carrying on those experiments, he has turned his attention to what they are doing in Germany ; and some time ago the Directors published a letter which he addressed to them upon the subject, and he states in it, " I am satisfied these experiments " (namely, " those conducted in Scotland under the charge " of farmers) will never lead to any definite results. " I do not think farmers and their servants are " qualified ; nor, if they were, have they the time " to carry out, with the requisite care and accuracy, " experiments from which scientific deductions can " safely be drawn. It requires far more care and " attention than they can be expected to bestow, in " order to conduct such experiments aright. Dr. " Nobbe remarks, that, at his station, they are in " the fortunate position of being able to get rid of " field experiments, by which I understand him to " mean field experiments on a large scale, under- " taken for farmers, which, he says, often give dubious " results. He is in favour of small plots, because " it is easier, he says, with some care, to obtain " a real uniformity in the conditions of vegetation,

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

“and to follow the plants minutely during their growth. I have had some experience as one of those who have been conducting the society's experiments during the last four years, and I can truly corroborate Dr. Nobbe's remarks. With every desire to conduct the experiments under my charge with as much care and accuracy as possible, I cannot say that I have, in all respects, succeeded as I could have wished, or that the results are such as to warrant strictly scientific conclusions being drawn from them. I can easily understand, therefore, how Dr. Nobbe considers himself fortunate in getting rid of such experiments in his scientific investigation. It does not follow from this, however, that they are altogether valueless. They have a certain value of their own, and useful hints, in practice, may be gathered from them; but, for *scientific* purposes, it is not too much to say, they are of no value whatever. It surely then becomes a question for the society, whether a continuance of the present system should be persisted in, especially seeing the immense success that has attended experimental stations on the continent, the value of which it has been my endeavour — imperfectly I must admit — to bring before you.” In the course of his letter he mentions how those stations are supported. He says, “The necessary funds in Germany are raised partly by subscriptions from agricultural societies and partly by grants from Government; and, in some instances, small stations have been established by private individuals on their own account.” But I have more particularly a letter from the Chemist of the Society, Dr. Anderson of Glasgow, an officer of the Society:—

“Chemical Laboratory,
“University of Glasgow,
June 22, 1872.

“Dear Sir,

“During the present century the improvement of agriculture has occupied more attention, and has been taken up in a more broadly scientific spirit in Germany than in any other country. The exertions which have been made, have been of a twofold character, and have resulted, firstly, in the establishment of a number of agricultural schools or colleges of so complete a kind that they might almost be described as agricultural universities, in which a thorough knowledge both of the science and practice of agriculture may be obtained. The consequence of this has been, that there has arisen in Germany a class of farmers who have no parallel in this country, who bring to the practice of their art a thorough knowledge of principles which enables them to take advantage of every improvement, so that the improvements in agricultural machinery which our manufacturing superiority has enabled us to introduce, are nearly as well known in Germany as they are in this country. The knowledge of principles which these schools establish, has also led to extraordinary interest in the development of the science of agriculture, and to the foundation of a number of agricultural experimental stations devoted to its study and improvement. The first of these stations was established at Moeckern in 1851, and their number has increased until now, including Austria, it considerably exceeds 20. Each of these stations is under the direction of a chemist with a proper staff of assistants, &c., and is carried on at an annual cost of from 400*l.* to 500*l.*, so that the total outlay in Germany, cannot fall short of 10,000*l.* or 12,000*l.* during a year. The funds for the support of these stations are derived from several sources, but a large portion (I should suppose, in round numbers, about a half,) is supplied by Government. The rest is contributed by the different agricultural societies and large landed proprietors in different districts. Some of the stations are provided with gardens or pieces of land on which field experiments can be made, others confine themselves to more purely scientific inquiries, and the particular form of action is often influenced by local circumstances. Thus, there are several which are occupied with the cultivation of the grape and manufacture of wine. In the beetroot-sugar districts the cultivation of that root attracts especial attention, and in others the feeding of cattle and dairy farming are more particularly studied. Since the year 1859, a journal has been regularly published, in which the results of the investigations made at the stations appear, and among the papers published there are a number of communications of great merit. Experimental stations have of late years been established in other countries. In Switzerland, Italy, and France they have taken root, and one was established last year in Belgium. The advisability of founding a similar station has been for some time back under discussion by the Highland and Agricultural Society, but the deliberations are not so far advanced as to enable me to make any definite statements regarding the plans which may eventually be adopted. The pecuniary question is one of the greatest difficulties to be encountered, for it has become evident to all of those who have studied the question that 1,000*l.* a year is the minimum on which such a station could be supported in this country, and it is even doubtful whether this would suffice; and some very experienced persons with whom I have consulted, think double this sum would be required, and it is very questionable whether such an outlay could be met otherwise than by Government endowment.”

12,531. Do you know whether the experiments thus made in Germany have led to any important results?—I cannot answer that question. Reports are published, but I know that most of our scientific agriculturalists in this country look chiefly to Germany for the principles of the science with regard to new manures and other points.

12,532. And is there not something of the kind done in Ireland? There are some model experimental farms maintained at the Government expense in Ireland?—There are farms attached to schools in Ireland. At the Larne and the Glasnevin schools, and one or two other establishments, there are plots of land set apart, but that is not so much for the purpose of original research as for giving instruction in the known principles of agriculture to the students. I may mention that it was the boys from the Larne Agricultural School which led to the establishment of the Agricultural and Chemistry Society in Scotland. When it was seen how easily knowledge could be acquired in schools and given to boys, that circumstance induced us to get the parochial schoolmasters in Scotland to take it up; but I am not aware that in Ireland there are any funds for making original discoveries; it is merely for teaching existing knowledge.

12,533. (*Dr. Sharpey.*) Are you aware whether much is done in France in the way of agricultural experiments?—The French Government had, some years ago, several institutions for teaching young men the principles and practice of agriculture. There are three that I know of, and one of them I visited.

12,534. Is M. Boussingault connected with any public experimental establishment?—I do not know.

12,535. (*Chairman.*) With respect to the Geological Society of Edinburgh, have you any statement to make to the Commission?—I think that the Memorial which is signed by the President and Professors is so full that it is hardly necessary for me to say anything more. But, perhaps, I may be permitted to read a portion of a letter from the Secretary which bears upon the point put very strongly in the memorial, namely, that the chief members of it are persons in humble life, who cannot afford to give more than 10*s.* or 12*s.* a year. The Secretary writes to me, “I beg to hand the memorial of the Council to the Royal Commission, as also a formal letter of authority to appear in our behalf. I promised to inform you as to the scientific work done by members of our society of small means or belonging to the artisan class. I beg to refer you to the accompanying three volumes of Transactions which I send for presentation to the Commissioners in the terms of

D. Milne-Home, Esq., LL.D., F.R.S.E.

26 June 1872.

" the memorial; Vol. I., part 1., p. 13, on the Lower " Carboniferous Rocks, &c., was written by a small " grocer; p. 18, Notice &c., by a working joiner," and a number of other small tradesmen, of whom he specifies a law clerk at a small salary, a grocer, and a working joiner. This society was formed in the year 1834, but it was not until the year 1864 that the funds had gathered, so as to enable them to publish Transactions, and the memoirs in this volume are very interesting and valuable. There are a great many other memoirs which they have not been able to publish from want of funds. A little aid to a society of this kind seems peculiarly called for, in consequence of the poverty of their members, and the great value of their Transactions. The Geological Society of Glasgow is much in the same position.

12,536. Has it ever been considered, with regard to these societies, whether it would be practicable to have two classes of members, some paying a somewhat larger annual subscription, one class who would be able to pay, say, 10*s.* or 12*s.* a year, and another class more?—I do not know whether that has been considered or not, but you will observe that in Edinburgh, where the Royal Society exists, a society which also attends to geology, there is not much inducement for members to belong to both societies, and to pay a large annual subscription to both. Those persons who are able to give three or four guineas a year join the Royal Society, and would not give a large annual subscription to any other society with similar objects.

12,537. Then, the Geological Society of Edinburgh is mainly intended for persons in a humble sphere of life?—I do not know that it was so intended, but the effect has been that it is joined mostly by persons in a humble line of life.

12,538. I think it is stated in the memorial that a grant of 50*l.* would put the society financially in a very satisfactory position?—Yes; the secretary in his letter mentions that. [*See* APPENDIX XV.]

12,539. (*Sir J. P. Kay-Shuttleworth.*) In the course of recent years, what would be your opinion with regard to its application to the purposes of scientific observation and research, as respects Scotland; has it increased considerably?—I do not think it has increased.

12,540. I mean, have private contributions remarkably increased for the purpose of encouraging scientific observation and research?—The only case that I know, is the establishment of the Scotch Meteorological Society; I am not aware whether the Honorable Baronet means any new society.

12,541. I mean not only any new society, but contributions towards existing societies; have they been considerably increased?—To the Royal Society there has been an addition during the last 10 years of some 40 or 50 members.

12,542. During the last quarter of a century, in England as well as in Scotland, the resources of society have very greatly increased, have they not?—Yes.

12,543. So that the wealth of Scotland is much greater than it was before?—Yes, it is increased, as other parts of the kingdom have increased.

12,544. The resources of the Government from taxation for all purposes must have also been very greatly augmented? Yes. I think there is a general feeling in Scotland that the public, perhaps, have done enough, and that the Government has done too little. At least we discovered that, when the Meteorological Society appealed to the public at the suggestion of the Chancellor of the Exchequer.

12,545. My object in this question is rather to point out that with the very great increase in the resources of the country, both private and public, there has been, so far as you can see, no very great increase of the application of the public wealth towards objects of scientific observation and research?—No. But whilst there has been a great increase of wealth in the country, it is right to keep in view that there has been also a great increase of burdens, at least on all heritable property, whereby the resources of Government have increased. For instance, in my own county, during the last 22 years, there has been an increase in the rental to the amount of 43 per cent., but there has been an increase of the burdens upon land, to the extent of 180 per cent.

12,546. But looking at the whole of the capitalists of the country, it would be necessary to take into account not simply the revenue from land, but the revenue from profits of trade and from accumulations from profits of trade; and, taking into account the increase of wealth from all those sources, there does not appear to be now applied to the purposes of scientific observation and research an amount proportionate to the increase of the wealth of the country?—That is quite true, I think; the backwardness of the Government to aid science, has not had a favourable effect on the willingness of the public to give aid.

12,547. (*Chairman.*) Are there any additions that you would like to make to your evidence?—Merely this, I see that the employment of the 1,000*l.* grant is stated in the parliamentary estimates in this way: " 1,000*l.* to the Royal Society of London to enable " the society to carry on certain experiments for a " public object." By this representation, it seems as if it belonged to the society and not to the whole nation. That is an additional reason why it is not known in Scotland. This inaccuracy in the parliamentary estimates ought to be corrected. I would also respectfully call the special attention of the Commissioners to a statement appended to the Memorial from the Royal Society of Edinburgh, showing the very large amount of parliamentary grants given for art, education, and science in Ireland, as compared with such grants given in Scotland. From that statement it will be seen that the grants to Ireland are four times greater than to Scotland, whilst, as shown in the memorial, the Imperial Treasury draws from Ireland (for inland revenue, customs, and post office) 6,500,000*l.* sterling, and from Scotland 9,000,000*l.* sterling; and whilst in Ireland every individual of the population contributes to the Imperial Treasury 1*l.* 4*s.* yearly, in Scotland every individual contributes 2*l.* 16*s.* yearly. [*See* APPENDIX XIV.]

The witness withdrew.

Adjourned.

No. 6, Old Palace Yard, Westminster, Friday, 5th July 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872.

Major-General SIR HENRY C. RAWLINSON, K.C.B., LL.D., D.C.L., F.R.S., P.R.G.S., examined.

12,548. (*Chairman.*) You are President of the Royal Geographical Society?—Yes.

12,549. I believe, to a certain extent, relations exist between the Government and that society: will you be so good as to explain to us the nature of those relations?—The Government consults the Royal

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872

Geographical Society upon very numerous matters. I have a memorandum which I can read to the Commission if they wish, stating the nature and extent of our relations with the Government.

12,550. We shall be very much obliged to you if you will read that paper?—"The chief subject on which the Royal Geographical Society has dealings with the Government is that of expeditions for geographical and general scientific investigation. During its whole existence, of 42 years, the society has had, on numerous occasions, to apply to Government, either for pecuniary aid to an expedition organised by the society, or to recommend the Government itself to undertake expeditions, such, for example, as those to the Arctic regions, the interior and the northern parts of Australia, and so forth. The action of the Government, though generally liberal in these matters, has been uncertain, and, apparently, guided by no principle or motive beyond the opinions and feelings of the Minister of the day."

12,551. Will you give some instances in illustration of this?—In 1856 the Council asked the Government to contribute towards Captain Burton's East African Expedition, which resulted in the discovery of Lake Tanganyika. The Government gave 1,000*l.* without any further pressure than a council deputation waiting on the Foreign Minister and submitting a statement of the objects of the expedition, and the route proposed. In 1860 (January 9th), the Council having applied to the Foreign Office to aid Captain Speke's Expedition to the sources of the Nile, a grant of 2,500*l.* was sanctioned by Lord Russell. During the six years from 1858 to 1864, the cost of Livingstone's great Zambesi Expedition was defrayed by Her Majesty's Government; it is believed to have amounted to upwards of 50,000*l.* The Council of the Society took no part in promoting this expedition; it was done through the Admiralty. In August 1865, the Government refused to contribute to Dr. Livingstone's Central African Expedition (the one in which he is now engaged) beyond a subscription of 500*l.* A salary to Livingstone as consul was refused. In 1870 the President solicited the Foreign Minister for aid for Livingstone, then reported destitute. The application was refused by the Foreign Office, but granted a few weeks after by the Treasury to the extent of 1,000*l.* In 1871-72 our application for aid towards Dawson's Expedition was peremptorily refused. The Government formerly devoted large means to the despatch of expeditions for scientific research to the Arctic and Antarctic regions. In recent years it has declined to undertake such expeditions; at least, a deputation of the Royal Geographical Society's Council in 1865 to the First Lord, recommending an Arctic expedition, met with no success. Yet, owing to the great advance in all branches of science, the arising of new problems, and the perfecting of scientific instruments for observation impracticable in former times, there is much greater necessity for such expeditions now than there was in the days of Parry, Franklin, and the Rosses. That is a brief recapitulation of the applications which have been recently made to the Government by the Royal Geographical Society. It shows the very uncertain and spasmodic (if I may so speak) action of the Government in these matters.

12,552. Has any remedy presented itself to your mind for the spasmodic action on the part of the Government?—The remedy which naturally suggests itself is the nomination of a permanent council of science, which would produce uniformity of action. I presume that such a council, by continuing to act for a certain time, would create traditions and rules of office which would be equally applicable on all occasions, whatever party might be in power, or whoever might be the Minister of the day. It appears to me that the chief and most important point in this matter has reference to the appointment of a council rather than to the nomination of a Minister. I think with a consultative council of science there would be a corresponding uniformity of action.

12,553. Have you considered how you would wish such a council to be constituted?—I have recently done so. I had not given much attention to the subject before, but I have recently studied the propositions of Colonel Strange and of General Strachey, and although I agree with both of them in general principles, yet I do not exactly agree in details. It seems to me that both of those schemes are objectionable in certain particulars. I think that Colonel Strange's council, in the first place, is unnecessarily expensive, and, in the second place, that it is too cumbrous and unwieldly ever to act with effect. On the other hand, I think that General Strachey's proposal for the mere continuance of an unpaid commission would not produce the results which he contemplates, and which we all desire. I believe that, to insure a due sense of responsibility, there must be some remuneration. The number of members on the council would seem to be of no great importance; it might be 9, or 11, or it might be 15. I should recommend a number within those limits. I think that the members should receive a certain salary, in order to make them feel a sense of responsibility, and to give due weight to the advice they might offer to the Minister. The amount of that salary is a matter of detail which might be settled hereafter. I should not propose that the members gave up the whole of their time to the business of the council, for I think it would be sufficient to call them together for a meeting, say, once a week, or even once a fortnight. I should think that a salary of 500*l.* a year would be quite sufficient remuneration, and, without entailing any great expense, would just fulfil the condition which I think so desirable in the constitution of such a council.

12,554. Do you think it desirable that any of the members of such a council should hold their places *ex officio*?—No. I would rather leave the nomination of the council to the Minister of the day. I do not see any necessity for creating a special ministry of science. I think the Minister of Education, as he acts in educational matters with a Council of Education, might very well act in scientific matters with a council of science, and I think the nomination of the council of science should be at his discretion.

12,555. You are aware that there is not, strictly speaking, a Minister of Education at the present time?—I refer to the Lord President of the Council, who is, *ex officio*, minister for education and minister for science; there is, indeed, an Education Department and a Science and Art Department of the Government under the Lord President at the present time.

12,556. You think he might undertake any duties of this kind?—Yes, with the assistance of a council of science.

12,557. On the subjects that you have brought forward as instances, I suppose the Government could not, in reality, obtain better advice than was available from the Council of the Royal Geographical Society; but do you think that advice given by a council, such as you have suggested, would be more likely to receive attention?—Yes. The Council of the Geographical Society no doubt supplies full and reliable information, but the reception of that information has hitherto rested upon the caprice, so to speak, of the Minister, the reasons being not generally—very rarely, in fact—given, either for accepting or refusing an application, so that the Council of the Geographical Society never knows what answer it will receive to an application, whatever may be the pressing urgency of the case. The very same application, indeed, founded upon the same grounds, will in one case be acceded to, and in an other be refused.

12,558. Might not that apply, to some extent, even in the case of this proposed council? You would not make it absolutely necessary for the Minister to follow the advice given by this council. You must leave a certain amount of discretion, I suppose, to the Minister, under any circumstances?—Certainly. In judging of the functions and the power of the council I have been guided in some degree by the precedent, with

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872

which I am well acquainted, afforded by the action of the Council of India. In that Council the Minister who presides has it always in his power to overrule the opinion of the Council; but, as a matter of fact, he almost always yields to an unanimous Council, and, in ordinary matters, to the majority of the Council. It is only upon questions of finance, where the power by law rests with the Council, that he can be overruled, but in the case of a council of science I should not propose that they should have any financial power at all. It would be a purely consultative council for scientific purposes, and I presume that the Minister of the day would on all ordinary occasions defer to their judgment, as they would be the best qualified parties to afford him advice.

12,559. With respect to the Indian Council, supposing the Minister refuses to adopt the advice of the Council, is any report prepared which would enable the public to judge of the merits of the case between the Minister and the Council?—It is provided by Act of Parliament that on all occasions where there is a divergence of opinion, any member of the Council may record his dissent, which dissent is circulated and preserved in the records, and may at any time be called for by Parliament. In very many cases such dissents or protests have been called for by Parliament, and thus published to the world, thereby acting, no doubt, as a check upon the power of the Minister.

12,560. And you would probably recommend the adoption of a similar practice in the case of a scientific council?—I think so; I think that would be desirable.

12,561. (*Dr. Sharpey.*) Might there not be a report by the scientific council upon any question submitted to them, whether they agreed with the Minister or not, because that would furnish the answer to an application of a body like the Council of the Geographical Society. You would know the reason why any application was either acceded to or refused, and the world would know it also?—I think it would be very desirable, that a sort of *procès verbal* should be drawn up upon all such occasions, reciting the grounds upon which the application was either agreed to or refused. What we rather complain of at present is, that no reasons are given either for acceptance or for refusal.

12,562. (*Chairman.*) Do you think it desirable that this council should have the power, if it pleased, of initiating proposals, and asking the Government to consider them, or would you rather regard it principally as a consultative council which the Minister might have recourse to?—My impression hitherto has been that it should be merely a consultative council. I have not had opportunities of studying the subject very deeply, so I hope the Commission will not receive my statements as authoritative; they are simply offered for what they are worth. In the Council of India we have no power of initiation. The initiative rests with the Minister, or, practically, with the executive officers, acting, I may say, on the inspiration of the Minister, and the measures are only brought before the Council, in a subsequent stage, for their approval or disapproval.

12,563. The Admiralty is probably the department of State which now has the closest relations with science. If such a council as you have advised were established, do you think it would be advisable to transfer any of the present functions that devolve upon the Admiralty to the Minister of Education, or the Minister of Science?—I was not aware, until I read Admiral Richards' evidence, what a vast responsibility the Admiralty have had in regard to the scientific portion of that department. I perceive that the hydrographic expenses of the Admiralty mount up to 120,000*l.* a year, and I certainly should not contemplate a minister for science taking charge of all that expenditure. In the case of one single establishment, the Greenwich Observatory, it has occurred to me that it would be desirable that the council of science should have the control of it; but I cannot think that in regard to the ordinary surveys, or in the general hydrographic operations of the Admiralty, there would be any occasion for its interfering. Neither would it be necessary for the council to interfere with the practical experiments, which cost probably hundreds of thousands a year, and which are carried on at present under the Ordnance Department; I mean the experiments relating to arms of precision, projectiles, armour-plated vessels, &c., &c.

12,564. Still the Admiralty might be able, on various questions which would arise, to obtain valuable advice from this council, if they thought fit to apply to them?—I should think in all questions involving mathematical calculations that the Admiralty would derive benefit from the council, as also might the Ordnance Department and the other practical scientific departments of the Government. I may mention to the Commission, in reference to this subject, that the desirability of such a council is constantly brought to my observation through another channel; namely, through my duties in the Council of India, where we perpetually have references before us, which we are really unable to deal with. These references recall most forcibly to us, and very frequently, the necessity for the existence of such a council as I have proposed. I have jotted down this morning a few heads of such subjects which the Commission may like to hear, and, if further information is required, I shall be quite ready to answer any questions about them. The heads I allude to indicate the sort of scientific questions referred to us from India.

12,565. We shall be glad to hear them?—I may observe, to commence with, that it is of especial significance that, upon the majority of those references, we should be unable in the Council of India to give satisfactory answers, since we are in a better position than most other departments of the state, having men of considerable scientific attainments both upon the Council, and also attached to the office. We have, for instance, Sir William Baker upon the Council, and General Strachey and Colonel Strange both attached to the office; yet, notwithstanding their valuable aid, there are many subjects referred to us with which we are quite incompetent to deal. The first subject I have noted is the manufacture of iron and steel in connexion with the Kumaon Ironworks, the question having arisen whether it might be desirable for the Government to take that manufacture into its own hands. Secondly, there is the efflorescence of soda on irrigated lands. A very large portion of the Douab being thrown out of cultivation, in consequence of a deposit or an efflorescence of soda following upon the artificial irrigation of the lands, the Indian Governments refer to us to know how the evil is to be remedied, and we are really unable to answer. A third question refers to the constituent chemical ingredients in beer. The fermentation of beer is a matter which may involve a loss of 200,000*l.* or 300,000*l.* a year to the British Government, yet it appears practically to be quite an open question. We are of course unable to deal with it; and when we refer to the brewers, we get different opinions, the question being one of chemical analysis, on which the "experts" disagree. Another very large question has reference to the desiccation of land. Owing, it is said, to the destruction of the forests, a very large belt of country inside the Ghauts is becoming desiccated; that is, the monsoon does not penetrate as far inland as formerly, in consequence, as it is asserted, of the diminution of the forest. The extent of land so affected is a belt of between 50 and 100 miles along the range of the Ghauts. Then there is a question as to the construction of harbours around the coasts of India, which has given rise to most serious consideration. Many of these questions, I may observe, are practical and economical, but still there is a scientific element in almost all of them. In regard to this question, for instance, of the construction of harbours, we have sent out one of the best men we could get, namely, Mr. Robertson, for the purpose of examining locally all the various sites for harbours, but, after he has satisfied himself upon the local aptitude of the sites, there will remain a number of scientific questions to be considered, involving difficult points of physical

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872.

hydrography, which the Council of India is certainly incompetent to deal with. There are also canal projects generally. The Ganges canal, for instance, gave rise to a violent controversy, which lasted for many years between the late Sir Proby Cautley and Sir Arthur Cotton, and which, in fact, is not finished even at the present day, questions of hydraulics being involved, upon which the best engineers take different views, and similar questions are constantly cropping up. Then there is the whole subject of the construction of railways, and, as a part of it, the great controversy which is now going on in India upon the respective merits of the broad and narrow gauge. The system has now been adopted by the Government of India of using a narrow gauge instead of the old gauge of 5 feet 6 inches, all the new state railways being made upon the metric gauge; that is to say, a guage of 3 feet 3⅜ inches. Another matter of considerable importance is the founding of brass guns. We have in India a vast number of old brass guns which we supposed we should be able to melt up and recast; but, lately, from experiments made at Woolwich, we were informed that the art of founding brass guns was lost, that the same guns, in fact, cannot be founded now that were founded formerly, and that they have been obliged, accordingly, to give up any further attempts at Woolwich. We have since instituted a course of experiments in India under Colonel Maxwell, and he finds the same result there, so that, whatever be the reason, there can be no doubt as to the fact. Probably the real difference is in the improvement of the gunpowder, but the practical effect that we find is, that no brass gun cast at the present day will stand a moderate series of discharges, but that they all run or scrape at the mouth. Now this is a question which involves a large money expenditure, and in regard to which we do not know whether science or practice is at fault. Then there is the publication of works on the Fauna and Flora of India, which is always going on, and upon which we want scientific opinions as to the value of the researches. Otherwise we may be throwing away large sums of money upon what is not worth publishing. There are also a number of smaller scientific matters which I have placed at the end of my list, such as deep sea dredging; the Godavery works; irrigation works generally; mines, geological survey, great trigonometrical survey, observatories, tidal observations, and gauges, &c., &c., &c. References on all these subjects are constantly coming home, and we have no means of answering them in our own body, while it is very unsatisfactory to be obliged to send out for gratuitous information. We do sometimes, it is true, apply to individuals and sometimes to societies, but, in very many cases, I am afraid, the questions are shelved, because there is no competent and authoritative body to refer to.

12,566. Are you not afraid that, however able and eminent the members of the proposed consultative council might be, questions would, from time to time, arise which they also would find themselves unable to solve?—I think very possibly or very probably such questions would arise.

12,567. How would you recommend that they should proceed in such cases?—At any rate the members of the council of science would know themselves who were the best parties to refer to, and that is a sort of knowledge which we of the Indian Council do not possess.

12,568. Then you would contemplate the council taking advice from persons beyond its own limits?—Yes, I think they should take that advice when it is necessary, and I think they should pay for it. I think it would be hardly fair to expect that private individuals engaged in scientific researches, as all such researches occupy time and trouble, should furnish information gratuitously, especially when applied to by a council which was itself salaried.

12,569. Of how many members does the Indian Council consist?—The Indian Council consists of 15 members, all to be appointed, under the new Act of Parliament, by the Minister for India. The Council is divided into six committees. We transact the business of the office in committees in the first instance, and then, once a week, the members meet in full council, when all the papers that have been passed by the various committees during the week are read, and, if necessary, discussed; and if any question requires further discussion, the papers remain on the table for a week to be decided at the next council; but you will readily understand that, seeing that the Council of India has to control the whole operations and expenditure of that vast country in military, political, judicial, revenue, and financial matters, as well as public works, railways, and telegraphs, the amount of its work is very much more than could possibly come before a council of science.

12,570. (*Professor Stokes.*) Did you contemplate that the appointment of the members of the council should be for life, or for a limited number of years, or for the duration of the existing Ministry?—I think it would never do to have the council dependent upon the duration of the existing Ministry. I should recommend their appointment for a period of years. I think five years would be the best period, and I should recommend their being re-eligible, after retiring for a year.

12,571. Would you make provision that vacancies should occur from time to time, or would you change the whole council at once?—I should propose to retire not more than a third at a time. Before the transfer of the government of India, the Crown members of the Court of Directors were appointed in the same manner. The period of service was for six years, but, as it was necessary to introduce six members on the first occasion, the new directors were divided into three classes, in order to promote circulation, that is, two of them were to sit for the whole six years, two for four, and two for two years; but when once that operation of varying the date of entry had been gone through, the service would be uniformly for six years. I think that some arrangement of the same sort might be applied in this instance.

12,572. Do you contemplate that it would be necessary, in all probability, that the Ministry should require to consult the council so often as once a week or once a fortnight?—The Council of India, by Act of Parliament, is obliged to meet once a week, and that, I dare say, has somewhat influenced me in forming an opinion upon the subject. I do not see any necessity for meeting so often as once a week or even once a fortnight, but I think there ought to be a minimum attendance. I think the council should meet, certainly, at some fixed period; otherwise, if it were at the option of the Minister to call them together, they might become quite an inoperative body.

12,573. Questions might, from time to time, arise which involved a knowledge of science and upon which the Minister would wish to consult the council at once; therefore, I presume, you contemplate his having the power of calling such meetings as might be required?—Certainly.

12,574. But you would also fix a certain minimum, so that there should be a meeting, in any case, at certain times?—That is just what I would propose. I think the Minister should have the power of calling a special meeting of the council at any time, but that the council should not meet less frequently than once a fortnight. I do not think that that is too often, even if they merely met as a matter of form. I would not, at the same time, make it compulsory upon every member to attend. We have no limitation of that sort in the Indian Council. There is nothing in the Act of Parliament determining a quorum, nor is there any byelaw obliging so many councillors to attend, but we still find, in practice, that we do attend with much regularity. When a little relaxation is necessary, we make arrangements amongst ourselves for relieving each other, but, on the average, throughout the year there are certainly more than three quarters of the members attending every week.

12,575. If the number of meetings of this council,

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872.

which may be held in the course of the year, is very uncertain, and if it be left a good deal to the discretion of the members whether they attend or not, are you of opinion that it might work more smoothly if the remuneration were made according to a liberal scale for each day of attendance, than if a fixed salary were given?—I am aware that, in the case of many boards of mercantile directors, that rule is followed, and I am also aware that in the old Court of Directors of the East India Company there were fines for non-attendance, which were distributed among those who attended, but I do not like the system myself; I think it is rather a shopkeeping style of remuneration, and that it would not operate very strongly upon gentlemen who felt it their duty to attend. Perhaps it would be well to consider such a plan of remuneration if the members of the council were persons in business for whom every hour was of importance, but I did not contemplate that that would be the class of persons called to the council, and so I never gave this particular matter my full consideration.

12,576. (*Dr. Sharpey.*) I wished to put that question from a different point of view, namely, with the view of really finding out, practically, what ought to be given, not so much as an inducement to the members of the council to attend, but in order to afford a proper remuneration to the council for the time that was demanded of them. That would be a practical way of ascertaining it, if, in the commencement, at any rate, they were paid for attendance. I should not contemplate dividing the fees of the absentees amongst those who come, as is done on some boards. In the case of the General Medical Council, which is a body constituted by Parliament, the members are paid so much for their attendance, and it is conceived that in that way the question is practically solved of what is suitable as remuneration; whereas, if you begin with a salary it would be quite uncertain what amount of salary should be assigned to the members?—I do not think that my evidence upon a matter of this sort would be of any value to the Commission. It is a question upon which I am really unable to give a better opinion than anyone you might pick up at the corner of the street.

12,577. (*Professor Stokes.*) You contemplated, I think, that the whole of the time of the scientific men who were members of this council should not be taken up with that work?—Decidedly it should not.

12,578. Would you debar them from undertaking any other work which would tie them down to particular days?—I think that if they took the situation of paid members of the council of science, they should be prepared to attend upon such days as the Minister might summon them, and that they should make their other arrangements coincide with this duty. I do not consider that, by this, they would be debarred positively from taking other work. The attendance at the council might be inconvenient to them sometimes, but I think they should be prepared for that.

12,579. Then you would contemplate that only such men should accept the office of a member of the council as had their time so far at their own disposal that they could arrange their work indifferently for this day or that day?—I think that that would be desirable.

12,580. Would you contemplate that this consultative council should be in a confidential relation to the Minister, so that they should be a sort of intermediate body between the scientific men of the country and the Ministers, and be able to enter into the feelings of both bodies?—Yes, that would certainly be most desirable, because one of the most important functions, as I conceive, of the Minister in consultation with his council would be in relation to the scientific institutions of the country, with a view to their improvement, and possibly their re-organisation.

12,581. Would you contemplate, with a view to maintaining harmonious relations between the council and the Government, that the Minister himself, or, in his absence, some one connected with the Government, say an under-secretary, should take the chair?—Judging again from the example of the Indian Council, I think it would be advisable that there should be, annually, one of the actual council nominated as vice-president, to take the chair in the absence of the president. I think that that arrangement would be much more satisfactory than that one of the executive officers, which the under-secretaries are, should preside. It is only in the unavoidable absence of the Secretary of State for India that the vice-president presides.

12,582. (*Sir. J. P. Kay-Shuttleworth.*) Do you think that a salary of 500*l.* a year would be sufficient for a member of the proposed council of science?—I do not propose that these gentlemen should give up the whole of their time. It seems to me that 500*l.* a year is a sufficient retaining fee for a couple of hours' work once a week or once a fortnight. I do not imagine that the councillors are to undertake experimental research or any of the actual labour of science. They would merely devote their attention to the business of the council for a very limited time, and the whole scheme, it must be borne in mind, is merely a tentative process. If 500*l.* a year is not enough to obtain the services of such men, the amount must be raised. I only throw it out as a suggestion, for I am really not able to give any decided opinion upon the subject. I know that in the Indian Council, before the transfer of power from the Board of Directors to the Secretary of State in Council, the remuneration was 500*l.* a year. Afterwards, the Council of India had much more important functions to perform, having been entrusted with the control of the revenues of the whole of India, and it was necessary to obtain the services of a body of men who, in such a responsible position, should have the confidence of the country. I believe that it was mainly upon these considerations that the numbers were fixed at 15, and the salary was raised to 1,200*l.* a year.

12,583. But seeing that this council would represent whatever there might be in the executive Government to appreciate scientific subjects—that there would be referred to it all that class of questions which you have enumerated as coming at present for solution to the Council of India, for dealing with which you regard the council as incompetent, and that from other great departments of the State there might and certainly would come up questions of a cognate character for the consideration of the council—do you not think that such a council, if it were once regarded as a new and essential feature to the operations of the Government, would require a considerable sum for the discharge of its duties, and that it ought to be placed at once in a position of honour and of considerable emolument?—It very much depends upon the extent of the functions of the council, and the work they would have to do. I have not been able, as yet, to realise to myself what the precise extent of their work would be. There is a great deal to be said on both sides. I look upon the present scheme as a mere tentative process. The Minister would be able to judge how the scheme worked after a time, and he would come to Parliament for any further augmentation of the salaries which might be desirable. The salary of 500*l.* is only an idea I throw out, for I have no very strong opinion upon the subject, one way or the other.

12,584. The result would, to a great extent, depend upon the degree to which the Government was conscious of the need of such aid, and upon the number of questions which came before the Goverment which could be properly referred to such a council?—I imagine that the Government would principally feel the necessity of referring to the council, so far as the claims of science are concerned, in regard to practical questions. Experimental research is not a matter which the Government would take up voluntarily. Experimental research, or investigations in inorganic science, might, it is true, be pressed upon it from the outside, but I do not think, at present, in this practical

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872.

go-ahead age, that they would be thus pressed to any very great extent. I have heard, indeed, many people say that they think it is better that all such matters should be left to private organisation. For my own part, I think that Government encouragement to science is desirable, and I may say necessary, but still I do not think that it is required, or that it is advisable to carry such encouragement to the extent recommended by Colonel Strange.

12,585. But, without carrying it at all to the extent recommended by Colonel Strange, if the council were limited to a few men of pre-eminent qualifications, representing the scientific institutions of the country, that which I want to ascertain is, whether it would not, in the first instance, for the very purpose of making the experiment a fair and effectual one, be desirable to place the members of it in a position of considerable honour and emolument?—Certainly, it is desirable that they should be in a position of honour, in order to command consideration, but I doubt if such consideration would depend much upon the amount of salary they would receive.

12,586. (*Chairman.*) Do you think it is quite clear that all the members of the council should be persons of great scientific attainments, or might it be desirable that there should be a certain infusion of persons more connected with administrative work?—I think that, in all councils, it is desirable to combine as many qualifications, practical as well as scientific, as possible, and it would certainly be desirable to have some members skilled in administrative functions. I think, moreover, that all men of science, who are also educated men of the world, naturally have a sort of administrative aptitude; it is part of their education.

12,587. Should you apprehend that a minister would find it a very difficult task to constitute a council in such a manner as to command the confidence both of the public and of scientific persons?—No, I should think not. I should think a minister, with the latitude of selection which he would have in a country like this, would have no difficulty in bringing together a council of 10 or 15 gentlemen whose qualifications and reputation would command the respect of the world, and whose opinion would fortify him in his decisions, and be of great national benefit.

12,588. I believe the Royal Geographical Society receives a subsidy from the government of 500*l.* per annum. What is that sum voted for?—That sum was granted, as far as I remember, in the year 1854, for the purpose of keeping up, as the original grant says, a map room for general reference. In the original Treasury letter nothing was said about procuring maps, but we have always considered that to be an obligation which the grant entailed upon us, and we have consequently gone on year by year purchasing, or otherwise obtaining, all the maps that are published throughout Europe, in fact throughout the world, until now we have a collection of over 60,000. And we have recently built a very spacious and convenient room, 60 feet by 40 feet, for the purpose of exhibiting these maps to the public. If I might be allowed to refer to a memorandum which I have drawn up upon the subject, I think the information might be interesting to the Commission. The memorandum relates to inquiries made by the government offices respecting geography and topography at the library of the Royal Geographical Society. It is to this effect:—"The offices in communication with the Society are, the Foreign Office, the War Office, (Topographical Department), the Army Medical Board, and the Admiralty and Telegraph service. During the preliminary arrangements for the Abyssinian campaign, information of every kind respecting topography and other questions was furnished; and letters of thanks addressed by the heads of department were received by the Council of the Society. The Hudson Bay Territory Transfer caused much inquiry. Later, the San Juan boundary question (to be settled by arbitration) was the cause of frequent communication with the Foreign Office, and with Admiral Prevost, to whom was confided the management of this portion of the affair. The officers of the Hudson Bay Company (Mr. Dallas and others) obtained the requisite information, included in their evidence, from here. In the Red River difficulty, Mr. Laurence Oliphant consulted the materials here deposited, and expressed himself satisfied with the completeness of the materials for his special purpose. Captain Donald Cameron, who has just started on his survey and exploration of the 49th parallel of latitude, prepared for his expedition by continual consultation of the Royal Geographical Society's materials. The Telegraphic Department also consults the library in all difficult or obscure geographical questions, and evidently with satisfaction." I may add that the Foreign Office, a few months ago, referred to us for details regarding the geography of Central Asia, in connexion with the advances of Russia towards India, and we furnished them with full information. Another matter, upon which the Government recently referred to us, was with regard to the expedition of the Schlagintweits; some years ago the Indian Government did assist those gentlemen in their expedition to Thibet, and went to a very great expense for the publication of the results of their researches. However, the Government was rather disappointed with those results, and recently, therefore, when they applied for a further grant, in order to continue the publication, the question was referred to the Geographical Society; and, upon the report sent in by the Geographical Society, which was unfavourable to the general character of the researches, the Government decided to suspend any further payments on their behalf, and the publication has consequently been stopped.

12,589. (*Dr. Sharpey.*) I think the Marquis of Salisbury was the minister for India at that time?—Yes.

12,590. A reference of the same kind was made to the Royal Society, and I believe the answer was very much the same?—The answer of the Royal Society was equally unfavourable, I think. I mention these instances, to show that the Royal Geographical Society is of real public use, and is referred to by the Government upon questions of a public nature.

12,591. (*Chairman.*) Is it ever referred to by foreigners and by other persons not connected with the Government?—The rooms are visited not only by the Fellows of the Society, but by vast numbers of the public, in order to consult the maps. In fact, almost every traveller comes to the Geographical Society before he goes abroad if he intends to visit a country which is only partially known, in order to get information and consult our maps, and I have no doubt we do a great deal of good to the public in that way. Not only travellers, but merchants, engineers, miners, and other people engaged in business, either in Asia or in South America or in Australia, come to the Geographical Society in order to qualify for their work. We have long had it in contemplation to extend our sphere of utility by a gratuitous education, so to speak; that is, we propose to instruct travellers in taking observations and fitting themselves for travel, according to a plan which is alluded to in the "Hints for Travellers," a work that has been recently published under the auspices of the Council of the Geographical Society.

12,592. (*Professor Stokes.*) Are persons admitted to examine the maps by the introduction of a Fellow of the Society, or in what way?—The strict rule has been that they shall be introduced by a fellow; but, practically, any person going to the Geographical Society's rooms, and giving his card to the Secretary, is allowed to examine the maps upon merely stating what his purpose is, and why he requires the information. There is only one point on which we feel a little, I will not say aggrieved, but dissatisfied, and that is, that we have no large place of meeting. Our evening meetings are sometimes attended by 1,000 (or on special occasions as many as 1,500) people, and we have no place to accommodate them. It is quite

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872.

impossible that a private house can accommodate an assemblage of that sort. At present, owing to the liberality of the Senate of the London University, we are permitted to hold our meetings in their hall; but this convenience is entirely dependent upon their kindness and liberality; and it is, moreover, necessarily accompanied with some difficulty and hesitation on their part, because they are overrun with applications from other bodies. They were obliged, in fact, last year to pass a resolution that their hall was only to be available for educational purposes, and it is not quite clear that our meetings come under this head of educational purposes. However, we are extremely obliged to them, and we have hitherto profited by their kindness, but it would be much more satisfactory to us if Government would assist us in some way in obtaining some such accommodation as we require. We have hitherto speculated upon the possibility of there being a great central hall for the meetings of the scientific bodies in the new buildings at Burlington House, but that scheme appears to have fallen through. We still do not give up the hope of some day obtaining some such accommodation from the Government.

12,593. (*Chairman.*) Have you made any applications to the Government upon the subject?—Yes, we made application when the plans were in preparation for the new buildings in Burlington House, but not successfully. In fact, we were given to understand that the grant of 500*l.* a year was considered the total amount of Government assistance to which we were entitled; and, although we explained that we gave a *quid pro quo* for this money, in keeping up a public map office, we never received any satisfactory answer. It is proper that I should mention to the Commission that we have, from our own savings, expended a sum of 20,000*l.* in purchasing a freehold property in Saville Row, which is now available for the Society's ordinary purposes, and for the public map room. The house is our own property; we bought it with our own money, and we keep it up and exhibit the maps there, using, in fact, the courtyard, which we have covered over in the Crystal Palace fashion, for a map room, but we are quite unable to provide ourselves with a hall for our crowded evening meetings. We think that if there were such a council of science as has been proposed, our application for a public hall would be brought with more force, through that agency, to the notice of the Government.

12,594. (*Dr. Sharpey.*) Is there any space on your present property on which a hall could be built?—No, none whatever. There was a courtyard belonging to the house which we have covered over, thereby obtaining a room of 60 feet by 40 feet, which is entirely devoted to the exhibition of maps; and, if the worst came to the worst, at any time we might, in that place, accommodate 300 or 400 people, but accommodation for 300 or 400 people does not represent our requirements at all. We require room for 700 or 800; the ordinary meetings, on the average, consisting of about 500.

12,595. (*Chairman.*) Is there any inconvenience in holding your meetings apart from your collection of maps?—The place where we hold our meetings at present is within 100 yards of the map office. It is just across the street, so that there is really no inconvenience whatever; and even if it were at a distance of a street or two, there would be very little inconvenience, since we move the maps which are required for exhibition from the map room to the hall of the meeting, and take them back again afterwards. Practically, there is no inconvenience in having the map room separate from the place of meeting.

12,596. (*Dr. Sharpey.*) Supposing the Government were willing to supply the means, could a locality be obtained, in the near neighbourhood of your present house, which would be suitable for a meeting hall?—I am not aware whether it would be possible to find space in the Old Burlington House Court or not.

12,597. I do not mean there, because that seems to be all occupied, but is there any property that might be acquired in the neighbourhood?—We have no information upon that head.

12,598. Has the society formed any estimate of the expense of obtaining a hall of meeting?—I do not think we have ever called for any direct estimate, but we know pretty well what the hall would be likely to cost. We know, at any rate, what the building expenses might be. The land, of course, is very valuable in that locality; and that would be the chief expense. I may mention that two years ago, before we undertook the purchase of the property in Savile Row, during the presidency of Sir Roderick Murchison, we made a very urgent appeal to the Crown for land upon the embankment, for the purpose of building a hall. Our proposal then was that if the Government would give us the land we would build on it. If we had obtained a grant of Government land, we could, with the amount which we have now devoted to the purchase of land, have built premises quite sufficiently large to accommodate the public at our meetings, but, as that favour was not conceded to us, we were obliged to buy land of our own. We rather feel, as I say, dissatisfied on this account, because some half dozen of the smaller societies are provided with public accommodation in Burlington House. Independently of the Royal Society, which has a vested right there, there are several others, the Astronomical Society and the Linnæan, for example, which have been recently granted rooms.

12,599. (*Dr. Sharpey.*) And the Geological Society?—Yes. There are five or six of the smaller societies, the Linnæan Society, the Geological Society, the Chemical Society, and the Astronomical Society, which are all provided with accommodation.

12,600. And the Microscopical. I believe the Society of Antiquaries has more of a vested right. It is upon the same footing as the Royal Society?—On referring to my memorandum I see there are the Geological, the Linnæan, the Astronomical, the Chemical, and the Antiquaries.

12,601. (*Chairman.*) Then you consider that the annual grant of 500*l.* does not at all diminish your claim, because you render a *quid pro quo* to the Government for it?—Yes, that is our view of the case. Considering that we actually have laid out a large capital in purchasing land and in building the map office, that we keep it replenished, that we maintain also an establishment for the purpose of exhibiting the maps, and allow the public free access to the map room, we consider that we fully discharge our obligations to the Government for the grant of 500*l.* a year.

12,602. I think you spoke just now of advice that you give to persons proposing to travel?—Yes.

12,603. I think you spoke of giving instruction also?—We are thinking of organizing, if possible, some course of instruction. We have some very competent gentlemen in our map office at present, and with some extra expense, we might be able to instruct travellers in the method of taking ordinary astronomical observations; we might teach them, that is, the use of the sextant, the theodolite, the altitude and azimuth instrument, the barometer, and the boiling water apparatus, &c.

12,604. Did you propose to organise something of the nature of a course of lectures?—That I think is rather beyond our present proposal. It may come, however, in time.

12,605. Your proposal is that persons should be able to resort to your rooms in order to obtain instruction?—Yes; we have always taken great interest in the geographical instruction of the public, and have already organised various means of encouraging the study. For instance, we have lately instituted geographical prizes for the public schools, and this year 11 of the leading public schools of England have sent scholars to compete for our prizes, Eton taking the lead in the competition, which we were very glad to see. Eton and Liverpool, indeed, carried off all the prizes in this year's examination. A great impetus

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872.

has been thus given to the study of geography, and we receive communications now from many of the head-masters of schools upon the subject. In addition to our own prize examinations, we have applied to the Universities to include geography in the examinations which they propose to institute for certain public schools, and they have assented generally to our proposal. I have here the copy of a letter sent to the Vice-Chancellors of the Universities of Oxford and Cambridge from the President of the Council of the Royal Geographical Society, requesting that they will introduce the study of geography into their examinations. Geography is already one of the subjects of examination in the endowed schools, and we hope, owing to our agitation in the matter, that it will, before long, be a recognised element of education; that it will, in fact, be introduced into the regular curriculum in all the schools of the country.

12,606. (*Dr. Sharpey.*) Whence is the income of the Geographical Society derived?—The Geographical Society began in a very small way. It had no endowment; it began with a few hundred private subscribers, but it has gradually increased, until the numbers now amount to about 2,400. The income is derived from the subscriptions, and from the life compositions, and also from benefactions, which are left by gentlemen taking an interest in geographical study. I think there are about 3,000*l.* or 4,000*l.* at present invested from bequests, but our main sources of income consist in the subscriptions of our members and their life compositions.

12,607. Could you state what the aggregate income is?—The aggregate income is between 5,000*l.* and 6,000*l.*, I think, and we generally manage to invest about 1,000*l.* a year, which represents the life compositions. We consider, indeed, that we are bound to invest so much annually as shall give the life compounders an adequate lien upon the society.

12,608. The society has given aid from time to time, has it not, to scientific inquiries and expeditions?—It subscribes largely always. In some cases it sends expeditions out entirely from its own resources; in other cases it unites with the Government, and sometimes it merely grants gratuities, or heads a subscription. For instance, on this last occasion of the Livingstone Search Expedition, the Geographical Society headed the list of subscribers with 500*l.*, whilst the Government contributed nothing; by bringing, indeed, clearly before the public the objects which were in view, we obtained an aggregate subscription of over 5,000*l.*, a large portion of which is still unexpended.

12,609. What are the society's publications?—The society publishes a large volume yearly, illustrated and enriched with very valuable maps. It has, thus, ever since its institution in 1830, regularly published a volume yearly, and I consider that the series of these publications is one of the most valuable collections that we have in the whole annals of English science. As a proof, indeed, of our public utility, I may state that there is hardly a country in the world which will not be found to be more or less fully described and illustrated in the volumes of the Geographical Journal.

12,610. (*Chairman.*) I am not quite clear whether you have asked the Universities themselves to take any steps for the promotion of geographical instruction or not?—We have not called upon the Universities to institute any geographical Chairs. Perhaps I may be allowed to read our letter upon the subject, in order to show what our exact application to the Universities has been. The letter is as follows: "Our attention has been directed to a scheme initiated by the head-masters of certain public schools, which is now under the consideration of the Universities of Oxford and of Cambridge, and which has already been favourably reported on by the committees to whom it was referred in either University. The scheme contemplates the establishment of a system of examination of boys, at the ages of about 16 and 18, in all the first-grade schools of England and of reports on the general efficiency of the teaching in each school by examiners sent by the Universities, the boys being allowed to select for their examination any five subjects out of a specified list, subject to certain restrictions, which it is needless here to mention. We have observed with some regret that neither physical nor political geography is as yet specified in that list, and we address you in the hope that the governing body of your University may see reason to repair the omission before the scheme is finally arranged; and we beg the favour of your bringing this letter to their notice in a suitable manner. We would invite your attention to the fact that geography has always been regarded as an essential, though subordinate element of liberal education, having actually been taught with more or less success in all our great public schools. This fact was recognised in the report of the Public School Commissioners, who, however, specially recommended a more effective and methodical study of this subject. We desire also to point out that geography will become, very shortly, a large and clearly defined part of education in all the endowed schools of England, that is to say, in the very schools whose boys form the great majority of those affected by the proposed scheme of examination. This consideration is so important, that we submit to you the following extract from a letter received by us from the Secretary to the Commissioners of the Endowed Schools in answer to our inquiries:—'In reply to your letter, I beg to say that in all schemes in secondary education the Endowed Schools' Commissioners include geography, usually specifying physical and political geography among the necessary subjects of instruction in all departments of the school. When a school is organised in two departments, some knowledge of geography, among other subjects, is, as a rule, required as a qualification for admission into the upper or senior department.' We also beg to remind you that geography is one of the optional subjects in all examinations conducted by the Civil Service Commissioners, including those preparatory to entrance into the army, which are now undertaken by that Department. Geography is so intimately connected with studies already the subject of examination in the Universities of Oxford and Cambridge, that we feel assured they could not intend to exclude it from their list of optional subjects. The elements of political geography are the groundwork of history, and physical geography exhibits the field of natural science. The most learned of continental nations express this opinion by the character of their examinations; thus, in the higher forms of Prussian 'Gymnasia,' whose system seems to have furnished, in some degree, the model of the scheme now before the Universities, the pupils have to give one tenth of their time to geography, and have to pass a compulsory, not an optional, examination in it before they are allowed a certificate of fitness to enter an University. The growing importance of geographical teaching is well shown by the subjects selected by candidates who pass the examination of the Science and Art Department of the Committee of Council on Education at South Kensington. There are no less than 23 subjects, in any of which candidates may offer themselves for examination. Now it appears that in the year 1866, one ninth part of the papers thus set to candidates at their own option, were in physical geography, while in the present year, 1871, no less than one quarter of the papers so asked for, out of a total of 38,000, were in that one subject. They were also more numerous than those on any other subject. We would further point out the special importance of geography to Englishmen in the present age. The position of great and widely-scattered dependencies, the unprecedented extension of our commercial interests, the increased freedom of intercourse and closeness of connexion established by means of the steam ship and the telegraph between our country and all parts of the world, the progress of emi-

“gration binding us by ties of blood relationship to so many distant communities; all these are circumstances which vastly enhance the value of geographical knowledge. Great as its utility has always been, an acquaintance with the grand routes which commerce has followed, or is likely to follow, of the conditions under which civilisation has succeeded, or is likely to succeed, is far more useful now than it was in past times, when those traditions were established which influence the education of the present day. The use of geography in different professions has been so often alluded to in detail, that it becomes hardly necessary for us to enlarge upon it here, but it is a subject on which we, as the executive body of the Royal Geographical Society, feel ourselves justified in expressing a general opinion, because we know that among the Fellows of our Society are many of the foremost men in every one of the careers by which the greatness and the varied national life of England are maintained. The association of such men in the pursuit of geography is evidence of the importance of that science in the education of the most valuable classes of English gentlemen. We speak of geography, not as a barren catalogue of names and facts, but as a science that ought to be taught in a liberal way, with abundant appliances of maps, models, and illustrations. We feel we have earned a right to express an opinion that geography admits of being so taught, and of being made the subject of scientific examinations, by the experience we have gained, through the establishment of certain prizes by us for exceptionally good geographical attendance among the boys of first grade schools. We find, as a matter of fact, that geography is exceedingly well taught at some few large schools, and that, unless it is very ill-taught, it is everywhere apt to become a popular subject with both masters and boys. We also find that examinations in geography are capable of testing much more than the memory; they give evidence of clearness of apprehension and of power of statement, or breadth of view, and of style in composition. It may be worth mentioning, that having assigned extra marks for maps and sketches, though only as far as they are effective illustrations of what cannot otherwise be easily expressed, we have observed, in some cases, that this indirect encouragement to drawing has borne most satisfactory fruit. We look to the Universities, not only to rescue geography from being badly taught in the schools of England, but to raise it to an even higher standard then it has yet attained. It appears to be directly within the powers given to them by the proposed examination scheme to do so. They can improve the quality of the examinations, they can report on efficient and inefficient teaching, and, in this way, steadily develop geographical science into the form most suitable for the education of boys. Then, in a school well furnished with appliances for geographical teaching, the mere elements, which all ought to know, would be learnt in early boyhood with trifling difficulty, while the more advanced knowledge which older boys would require, who elected geography, either physical or political, as one of the subjects of their examination, would be obtained without waste of effort, and without burdening the memory with names to which no corresponding image existed in the mind. Geography so taught would appeal strongly to the imagination; it would be found to abound in instructive generalizations, and it would vastly increase the range of a schoolboy's interest and his materials for after reflection.” This letter, I may add, has been responded to favourably by most of the Universities.

12,611. Do you think that geography is a better subject for school education than for university education?—Yes, I think so. I should say that geography properly forms a part of earlier rather than of later education.

12,612. And so far as provision has hitherto been made for geographical instruction in the public schools, do you think that it is of a tolerably satisfactory character; have those who have come up to compete for your prizes shown considerable attainments?—Yes; in some schools the high scale of proficiency has been very remarkable. Until the present year, this high proficiency was limited pretty well to the schools of the north of England, that is, to Liverpool and Rossall in particular (and also Cheltenham College), but this year for the first time Eton has come into the lists and carried off two of the best prizes, the first prize in physical geography and the second prize in political geography; and we hope that the example of Eton will be followed in another year by Harrow and Rugby, and Winchester and Westminster, and the other great public schools. It is unquestioned that the improvement in the system of teaching geography has been very great during the last few years, since our encouragement of the study became generally known. The examiners, indeed, reported that no defects were traceable this year in the system of instruction. All the schools seemed to have taken up very much the same system of instruction, and there was no deficiency to be noted anywhere.

12,613. (*Sir J. P. Kay-Shuttleworth.*) Have the society taken any steps towards preparing a textbook of geography for the use of public schools, or towards encouraging persons to publish one?—That is one of the points we are now considering. We know that it is very desirable that there should be a manual of geography published under the auspices and with the authority of the Geographical Society, but it is rather a serious business. One of our difficulties is that the geography of the world is not by any means exhausted, and that we can thus only furnish geographical knowledge up to a certain point, the study being continually subject to improvement and extension. There are other practical difficulties, and, thus, although we have considered the matter seriously on several occasions, nothing has been determined as yet.

12,614. Has the Council had under its consideration the proper limits, and the method of instruction for boys of the age at which they attend the public schools?—Yes, in our public examinations we divide and classify geographical knowledge very carefully. We divide it, in the first place, into two heads, firstly, physical, and, secondly, political geography. We then give notice a year beforehand that we shall examine upon certain subjects, and the schools have accordingly to instruct their boys in that particular branch of the study. In political geography, we name certain specified counties, but in physical geography, we allow the examination to range over the whole world. In this number of the Proceedings of the Society (No. 3., Vol. XV.), the examination papers are given at length.

12,615. I am well aware, from communications I have received from Mr. Francis Galton, your secretary, that this subject has been very much under the consideration of the Council of the Society, and that the whole question of the method of instruction, and the preparation of a manual is under the continual attention of the Council?—Yes, that is so.

12,616. The defect of the present manuals is, no doubt, very apparent to the Council?—Yes.

12,617. (*Chairman.*) Are there any other matters upon which you think it would be desirable for you to make any additions to your evidence?—I think not. I think I have stated everything to the Commission with respect to which I really have any solid information to give.

12,618. (*Sir J. Lubbock.*) Did I rightly understand that neither Harrow, Rugby, Winchester, nor Westminster had yet competed at all for your geographical prizes?—I think they have not.

12,619. Is this year the first occasion upon which Eton has competed?—Yes. It was very satisfactory

Maj.-Gen. Sir H. C. Rawlinson, K.C.B., &c.

5 July 1872.

to us to see that Eton not only competed, but gained two prizes out of four, and that the two boys who gained those prizes were of the respective ages of 15 and 16, while the other competitors were of the ages of 17 and 18. „We attribute the success of Eton mainly to the great interest which Dr. Hornby has taken in the subject, and to the excellent system of instruction which he has inaugurated.

The witness withdrew.

Adjourned.

No. 6, Old Palace Yard, Westminster, Wednesday, 10th July 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
WILLIAM SHARPEY, ESQ., M.D., Sec. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

THOMAS HENRY FARRER, Esq., examined.

T. H. Farrer, Esq.

10 July 1872.

12,620. (*Chairman.*) What is the office which you hold in the Board of Trade?—I am permanent Secretary of the Board of Trade.

12,621. How long have you held that office?—I have held that office nearly seven years, but I previously held the office of Assistant Secretary of the Marine Department since 1850.

12,622. What business of the office is there which brings you into contact with scientific questions?—The Board of Trade is a sort of *omnium gatherum*, upon which a very great number of subjects are thrust. In fact I sometimes think generally when the Government or Parliament want to know what to do with any subject which does not belong to any other office it is sent to the Board of Trade. The business of the office at present is connected with the following, among other subjects, all of which have occasionally more or less to do with science. There is the business of the Government connected with railways, viz., the inspection of railways before they are opened, with inquiries into accidents, and various functions principally connected with the safety of the public in travelling. Then there is a very large department of the Board of Trade connected with ships, which has to do with the safety of passenger steamers, and has to survey the steamers, and to see also to the enforcing of the provisions of the law relating to the health of crews, to lime juice and to other provisions against scurvy, and disinfectants and matters of that kind. The same department has to deal with the deviation of the compasses; and also with inquiries into casualties happening to ships, in the course of which scientific questions sometimes arise.

12,623. The Royal Navy, I presume, is not in any shape included in your functions?—No, we have nothing whatever to do with the Royal Navy; nor do we build ships. Our function is to see that the ships that carry passengers are safe, and that certain provision of the law relating to the health of crews, the space in which they live, and so on, are complied with. Then another function of the Board of Trade, which brings us in contact with marine engineering, relates to harbours. The Board of Trade have certain functions in relation to private harbours, and there are two or three public harbours which are under their control. Then they have a great deal to do with the building and management of lighthouses, in the course of which a good many scientific questions arise. Then they have, under recent Acts of Parliament, a certain control over the gas supply in London, which, again, brings them in contact with chemical questions, but only in London. Such is the anomaly of administration; gas in the provinces, is, so far as any Government Department has to do with it, under the Local Government Board, whilst, for some inscrutable reason, gas in London has been placed under the Board of Trade. Then, again, the Board of Trade have to do with the water supply of London; but they have nothing to do with water supply elsewhere. Then they enforce the law concerning alkali works, the object of which is to prevent those works from sending out fumes which are destructive to vegetation and otherwise injurious, which function will probably be transferred to the Local Government Board. Then they have, under a recent Act of Parliament, the supervision of Mr. Chisholm's department, which takes charge of the standard weights and measures of the country. They have, also, under another recent Act of Parliament, certain powers with respect to the formation of beds for the propagation and fattening of oysters, and they administer the law with respect to sea fisheries, which brings them in contact with natural history questions.

12,624. The inland or river fisheries are under the Home Office, are they not?—Yes; such is the division of the work between the departments.

12,625. Transfers of work occasionally take place, do they not, from one department of the State to another?—Yes; I think I may say that every one of those functions which I have mentioned has either been created anew or transferred to the Board of Trade since I first joined it.

12,626. How do you deal with scientific questions arising on any of these subjects?—In different ways. Sometimes we deal with them through a regular staff of persons of practical and scientific knowledge appointed for the purpose, and on other occasions we are obliged to have recourse to persons specially appointed for the particular question, or to make inquiries of the trade, or to obtain information in any other way which the nature of the subject will admit of.

12,627. What scientific or *quasi* scientific staff have you?—Taking the different subjects which I have mentioned in succession: First, as regards railways, we have four engineer inspectors, who are officers of the Royal Engineers, lent to the Board of Trade by the War Department for the purpose, but practically permanent with us. With regard to ships, we have a set of examiners in navigation, who are, to a certain extent, scientific persons, and capable of helping the Board upon questions relating to that department of maritime practice. With regard to the safety of vessels, we have a large staff of surveyors at the different ports, who are persons brought up in the shipbuilding business, and in engine factories, and who are engaged in looking after the hull and the machinery of steamers, with a number of collateral duties; in fact, they are a sort of marine engineers, and they look after both the building of passenger ships, and after the engines. Then, with respect to harbours, we have an eminent officer of the scientific branch of the Admiralty, Admiral Bedford, a person who has passed his life in surveying under the Hydrographer, and he is our chief adviser upon this point. Then, we have, besides that, in the consulting and resident engineers, persons of the highest eminence in the profession, such as Mr. Hawkshaw and Sir John Coode. With respect to lighthouses, the Board of Trade have the immediate building only of British Imperial lighthouses abroad.

T. H. Farrer, Esq.

10 July 1872.

The lighthouses in this country are built and managed directly by three boards, namely, the Trinity House in England, the Irish Light Commissioners in Ireland, and the Northern Lights' Commissioners in Scotland. Admiral Bedford is our great adviser upon these points, and we are in close communication with the Trinity House and those other boards; in fact, they almost form a part of the Board of Trade. The Deputy Master and the Elder Brethren of the Trinity House themselves possess considerable scientific knowledge on the subject, and they have an excellent engineer, Mr. Douglas, who also possesses much scientific knowledge, both on the subject of building lighthouses, and on the subject of lighting apparatus. Then, upon questions connected with lighting apparatus, they and we are advised by Professor Tyndall. The Northern Lights' Commissioners have very eminent persons, well known in that branch of the profession, the Messrs. Stevensons, and the Irish Light Commissioners have also a very competent engineer. That is the permanent staff for the purposes of lighthouses.

12,628. Do you consider Professor Tyndall to be a member of your permanent staff?—In this sense, that, being the successor of Faraday, he receives a salary, and that is why I mentioned his name. We have a right to refer to him on any point connected with lighting.

12,629. Does he receive a salary connected with the department?—Yes; a small salary. Then, with respect to the gasworks in London, there are three persons, called gas referees, who are appointed under a recent Act, whose business it is to fix what shall be the test of the lighting power of gas, and what shall be the maximum of impurities in gas, and how those impurities shall be tested, and we have also Dr. Letheby, who, those tests being once fixed, is Chief Gas Examiner. Then for the waterworks in London a special engineer, Major Bolton, has been recently appointed, whose business it is to inspect the works of the companies from time to time, in order to see that there is a proper filtering apparatus, and that all proper means are taken for purifying the water. With regard to the control of alkali works, which raised a new question, and really a scientific one, Dr. Angus Smith has been appointed, with a staff of sub-inspectors. With regard to weights and measures, we have the Warden of the Standards, Mr. Chisholm, who has already been before this Commission, and who has learnt his science, I believe, in the practice of his department, and who has been much assisted hitherto by a Royal Commission. With regard to oyster fisheries and sea fisheries, we have a permanent inspector, Mr. Pennell. That is, I believe, our permanent staff.

12,630. Do you often feel the need of further scientific help, and when you do, how do you proceed to get it?—We very often feel the need of help on particular questions, and we get at it in the way that we best can, by going to persons who, we think, know most about it, sometimes by inquiry amongst the trade and amongst practical men, sometimes by inquiry at the Admiralty, or other public offices, sometimes by a reference to a Royal Commission, and sometimes by a reference to scientific persons.

12,631. Can you mention any instances of this, and the mode in which you have dealt with them?—I have a long list of cases which I could give if the Commission would not think it wearisome. Years ago there was a question as to the strength of railway girders, that is to say, our inspecting officers wanted to know what sort of bridges they should sanction as safe before the opening of a line, and a Royal Commission was appointed for that purpose, consisting of the best men who could be found at that time. Then we had a question in surveying ships, when iron ships came into vogue, as to what should be the strength of angle irons and plates for ships, and so on. For that purpose we consulted Lloyds and Lloyds' surveyors, and laid down the best rules that we could. Recently we have had a question as to the material and mode of construction of steam pipes, in what way they should be constructed so as to be safe. In that case a very excellent officer of our own, now dead, raised a question, with regard to which, eventually, he proved to be in the wrong. I mention that as showing the necessity that we have for going out of doors. A complaint was at once made about his view of the matter. We referred to all the practical builders, to the engine makers, and to the owners and managers of steamships, and we were enabled, in that way, to ascertain what was really safe, and what rules we could lay down upon the subject. Then, another question that we have had was with regard to the size and character of safety valves. With respect to that, again, we consulted the most eminent of the engineers, such as Mr. Penn and people of that description, and we were enabled to arrive at a conclusion upon the matter. Then, we had a question with Lloyds' about the mode of testing chain cables. Our surveyor and their surveyor were at variance. We asked Mr. Hawkshaw, Mr. Fairbairn, Mr. Hick, and Sir William Armstrong whether they would undertake to investigate and settle the question for us. They did so, and they decided that our surveyor was right and that Lloyds' surveyors were wrong, and our rule has been adopted. Then with regard to the deviation of compasses, that was peculiarly a scientific question, and a very difficult one. Upon that subject we had a very great deal of scientific advice, in the first place from Professor Faraday. Afterwards we made a grant for experiments, which were carried out by Mr. Towson and Mr. Rundell, very competent persons, at Liverpool, and they made and published a series of experiments. We had also the greatest possible assistance from the compass department of the Admiralty, who had of course made very important investigations and experiments for themselves; and we have had advice from the Astronomer Royal, which was not always in accordance with the views of the Admiralty Department; and we have had advice from the Royal Society, who not only volunteered us advice, as to the mode in which the thing should be done, but undertook to tell us what we ought to do, which we thought was stepping a little beyond their department. We thought we were judges whether steps ought or ought not to be taken of the public safety, but that if they could tell us how the thing required could be done we should be very much obliged to them. Then we have had a good deal of scientific work connected with the electric light, upon which Professor Faraday looked with great favour as a beautiful illustration of the truths of science, and Professor Tyndall also, and the work has been done, under the Trinity House, by Mr. Holmes under the superintendence of Professor Tyndall. We have had recently a question as to the introduction of paraffin in lighthouses. The question is a very important one, since it illustrates how those things work themselves out. We were in considerable difficulty about the use of paraffin at first. It was obvious that it would give a cheap and excellent light, but there was considerable danger in it. We were for some time in doubt what to do, and many trials were made by the Northern Lights' Commissioners. That question has now pretty well solved itself; for it was very much to the interest of the trade of the lamp makers and the producers of paraffin to put it into such a shape that it could be used safely in lamps generally, and now, after a lapse of a couple of years, the question with us is not whether paraffin can be used or not, but how to choose amongst numerous inventors and patents. Gas, again, is now being introduced into lighthouses. It has been proposed to do it in former years. Recently a Mr. Wigham has proposed certain improvements in the mode of burning gas, which Professor Tyndall has approved highly of, and there is every prospect that it will be introduced. Then there is the question to which I alluded just now, of sulphur in gas. How to test the impurities of sulphur in gas is a question which is puzzling us at this moment. Referees have been appointed for some years, and they have come to something like a provisional conclusion; but they obviously have come to no final or certain conclusion upon the subject, and we are now considering in

T. H. Farrer, Esq.

10 July 1872.

what manner we can best solve that question. The present proposition is that we should appoint as gas referees, in place of the present referees, one or two of the most competent chemists that we can get, and ask them to conduct a series of investigations, if they think they can do that so as to lead to a satisfactory conclusion, and so as to produce a result that we can act upon. Then there is another point upon which we are in extreme difficulty at present, namely, in what manner to test the purity of water, because the chemists seem to be very much at fault upon it. We should be very glad if any scientific body or scientific persons could tell us whether that is a question which is now capable of solution. It is obviously one which it is well worth while to solve if it is capable of solution. It is possible that it is a thing that must wait for a few years before any practical test can be adopted. Then there is the larger question of the mode of using sewage, and how to get rid of the difficulties of sewage. The principal part of that question comes under the Local Government Board or the Home Office. We, however, have had to do with it, having had to introduce bills for the purification of the Thames and the Lea, connected with the London water, and for that, of course, we have referred to the various Commissions that have been appointed to consider that important subject. Then, to go to a totally different subject, we have had questions arising as to the reason for the scarcity of oysters, which many persons alleged was due entirely to their being overfished, and which other persons alleged was due to natural causes, and for that purpose a Royal Commission was appointed, on which Professor Huxley gave us first rate assistance. In the same way, a similar question arose with respect to the sea fisheries, namely, whether trawling, which is a most killing mode of taking fish, and a mode that is getting the upper hand of other modes of fishing, was destructive to the spawn and the breeding of fish. That subject was also referred to the same Commission, of which Professor Huxley was an active member. Then there is the subject of weights and measures, which is under Mr. Chisholm's management, but he has been assisted ever since it was handed over to him by the Royal Commission, consisting of most competent scientific men. I should like to explain exactly how this subject is managed in the Board of Trade, because I see some observations have been made concerning it in the evidence before this Commission. It has been stated, I think by Sir William Thomson, that the weights and measures are put under the Harbour Department of the Board of Trade, which sounds absurd enough; but the reason is this, that the Weights and Measures Department is necessarily a separate establishment, away from our central office. In order to keep the business in its proper course in the office, the papers that come into it must come through one of the departments in the office. That is our organization. If they do not do so, they would come direct to me, and they would not get so well treated or so well dealt with as if they came through some subordinate officer first. Mr. Chisholm is an excellent administrator, and has obtained great scientific knowledge on that part of the subject; but he is not a lawyer, and it is to be remembered that our business with regard to weights and measures is not only to see that the weights and measures are strictly accurate, but also to see that, by administration of the law, or, if necessary, by amendment of the law, the weights and measures used are such as will protect poor people, or, at any rate, enable them to protect themselves from cheating. It is that very rough and coarse function which is our principal function, and that has to be borne in mind. When Sir William Thomson speaks of the very fine scientific purposes to which the Weights and Measures Department is to be extended, it is to be remembered that our primary function is to see that each old woman in the country is able to know whether she is cheated or not in buying her pound of tea. For that purpose there is a great deal of law involved in dealing with the police, with vestries and with other local bodies, and, as Mr. Chisholm is not a lawyer, it was thought desirable that the papers should come under the hands of a competent lawyer at the Board of Trade, and as the Assistant Secretary of the Harbour Department is a very competent lawyer, and as that department is less overwhelmed with work than any other legal department of the Board of Trade, it was arranged that Mr. Chisholm's papers should come through Mr. Trevor to myself, and so to the political heads of the department.

12,632. In fact it is rather connected with the particular officers of the Harbour Department than with the Harbour Department itself?—Yes. As I tell you, the Board of Trade has been a waste-paper basket, into which miscellaneous business of all sorts is put. When new work comes to us we are obliged to put it into the best pigeon-hole we can, and, at any rate, so to deal with it that we shall know where to refer and where to find papers. For all those purposes, it is necessary that each subject should be attached to some department in the Board of Trade.

12,633. Have you, as a rule, been able, by those means, to overcome the difficulties with which you have had to contend?—In general we have been able to do so in one way or another; but we are every now and then in very considerable difficulty on different points. For instance, where we have a scientific officer and the permanent and political civil heads of the department know (as must generally be the case) less than he does upon the subject, although they may suspect that he may be wrong, they have no regular means of testing that point or not; and they are obliged to take the best means they can. It is very desirable that, for these purposes, the department should have the power of referring to some undoubted scientific authority. Then, again, questions arise upon which no professional officer in the Board of Trade professes to have any knowledge at all. On those subjects we want to refer to a scientific body to tell us, as in the case of the water test, whether the question raised is one which, in the present state of science, is capable of solution, and if it is, what is the best way of solving the question; or, in other words, who are the best persons to go to in whose hands to put the solution of the question.

12,634. Have you any suggestions to offer as to the best modes, as it appears to you, of solving problems which, from time to time, present themselves?—I think if, upon purely scientific questions, there were some scientific body of some kind to whom the Government departments could, as a matter of course, refer for the solution of such questions as this, it would be a great advantage.

12,635. Have you thought how such a scientific body could best be constituted?—I think that the constitution of any such scientific body must be considered in connexion with another function, which is a totally different one from that which I have been considering. I have been considering questions that arise in the course of administration where the Government want scientific help; but there is a totally different function, and that is advising the Government upon questions of scientific research.

12,636. Do you draw any distinction between cases which are the subjects of practical arts and professions, and in which science has already established certain conclusions, and those in which knowledge is still in an embryo state?—Yes. I do not think that, as a general rule, we require assistance in those cases in which science has established well-known laws, and in which there are practical professions acting upon those laws. We very seldom need scientific assistance in such subjects as engineering or ship-building. In those cases which I have mentioned, questions for instance of the strength of iron ships, of the staying of boilers, of the strength of girders for iron bridges, those questions depend generally upon well-known laws of mechanics or metallurgy; and there are engineers, ship-builders, and others, educated to practise those laws in a well-known profession, who can

T. H. Farrer, Esq.

10 July 1872.

generally tell you more about what you want for the rough practical work of the Government surveys and inspections than you would get from a purely scientific investigation. I have looked at the suggestions that have been made by Colonel Strange and others, and I do not think that any Government department or its professional officers would listen to the dictation of any council of purely scientific men; they would probably say, and say with justice, that they knew more about what was wanted than any such council could know. Every now and then, in the course of practice in those cases, a new scientific question does arise; such, for instance, as the question concerning deviation of the compasses. In such a case as that, we required the best scientific assistance we could get; and, in the case of sulphur in gas, and water impurities, we now require it.

12,637. Do you imagine that it would be generally admitted that conclusions which can be deemed to be certain have been arrived at on those points on which you spoke just now, the strength of girders for instance?—I think that certain practical conclusions have been arrived at. The thing has been worked out by the ship-builders; for instance, when I first came to the Board of Trade, iron ship-building was in its infancy. The first iron ships were admirably built, and they were built by very eminent engineers. Then came a very great demand for iron ships, and inferior workmen were employed and inferior iron was employed, and there were great defects, but now the thing has cured itself. The shipowners found that the ships were very costly, that they were perpetually leaking, and there were difficulties as to the expense; and the shipbuilders themselves have worked out the problem better than any scientific commission could have done it for them. No experiments that any scientific persons can make are equal in number or importance to those which a practical trade or business makes for itself. Scientific help is not wanted in cases where, as in the case of mechanics, certain laws are well known and fixed. And, in the second place, scientific help is seldom or little wanted in those cases where it is the interest of a great number of traders and manufacturers to develope the manufacture themselves. I would instance what I have mentioned as regards the strength of iron and steel; the ship-builders have entirely done that. And with regard to the use of paraffine in lamps, the lamp makers have done or are doing it. In these cases of practical manufacture, plenty of practical experiments are sure to be made. But this is not the case where the Government are the sole manufacturers; for instance, in the case of guns, in the case of building ships of war, in the case of lighthouses,—in all those cases those are things which are done by the Government and by the Government only, and, therefore, in that case they may need scientific assistance, which they do not need in such a case as ordinary shipbuilding or ordinary engine making. Then there is another case which I would also make an exception; where the manufacture is a monopoly and where the Government has to control that monopoly; for instance, in the case of the gas supply and in the case of the water supply. The gas companies know very well that they have a monopoly, and that they can make with ease 10 per cent. whether the gas is good or bad, or whether it is pure or impure; and you then set up a Government machinery to control them, and the Government machinery which has to do that has need of scientific assistance to ascertain what it can do.

12,638. (*Professor Huxley.*) Did I properly understand you to say that you think it would be desirable to have a body of permanent scientific referees to whom the Government should naturally refer any questions of the kind of which you speak as the authorities?—Yes, I do think so. For instance, when the question arose whether the scarcity of oysters was due to overfishing, or was due to natural causes, a question involving a very difficult problem of natural history, the Government were in doubt, and needed a scientific referee. They did on that occasion call in and employ Professor Huxley. But, in such a case as that, it would be certainly an advantage to the Government Department to be able to have a body to refer to who could at once tell them whether the question is one which is capable of solution, and, if so, who is the best person to whom you can go to assist you to solve it. I think it would be a very useful thing to have a body of that sort.

12,639. (*Chairman.*) What has the Board of Trade done in the matter of meteorology?—A detailed account of the proceedings with respect to meteorology, previous to the year 1866, will be found in the report of the committee, consisting of Mr. Galton, appointed by the Royal Society, and Captain Evans, appointed by the Admiralty, and myself, in that year. In that year the whole proceedings were reviewed, and in that report which we made, the whole history of the detail, down to that time, will be found; and this is a short account of it, taken from a letter of my own, which is already before the Commission: "The subject " was originally undertaken at the request and under " the advice of the council of the Royal Society, and " not for the purpose of meeting any immediate want of " the Government. The object was two-fold; namely, " first, the furtherance of meteorological science generally; and, secondly, the establishment of rules for " the improvement of navigation. It was this latter " object which was the principal justification for the " expenditure of public money. The precise thing to " be done was to collect careful observations of the " meteorology of the ocean, a task which no private " observer could undertake. Accordingly, a programme was furnished by the council of the Royal " Society, an office was established, and a public " grant obtained. For some time observations were " continued on the original plan; but the officer who " had been charged with this duty soon diverted his " attention and the grant to the more popular and " practical object of foretelling weather in the British " Isles. The Board of Trade were not satisfied with " this diversion of the original grant, or with the " scientific foundations on which the new art of foretelling weather was based; but, being themselves " scientifically helpless, they applied to the council of " the Royal Society for advice. There was, however, " on the part of that body an obvious delicacy in " criticising the proceedings of an eminent and devoted public servant, and it was not until the post " had become vacant that any change was made." I purposely state that, because I think that it illustrates how valuable it would be for the Government to be able to refer, and to refer as a matter of course, to a scientific body, a scientific body which should feel itself responsible, and which should not, as the Royal Society, be purely voluntary, but which should be bound, from its position, to give the Government assistance on such subjects. In that case we felt, at the Board of Trade, that Admiral FitzRoy was premature in foretelling the weather; but he knew more about it than either Mr. Milner Gibson or anybody at the Board of Trade did. The council of the Royal Society very naturally felt a delicacy in interfering with him. Now we should have liked, in that case, to have had a body to whom we could go and of whom we should have a right to ask, "Are we going on in the right path or are we not?" "The subject was then " investigated by the committee above referred to " (which was jointly appointed by the council of the " Royal Society, the Admiralty, and the Board of " Trade), and the result has been that the amount and " scope of the parliamentary grant has been considerably " increased, so as to embrace observations by land in " the British Isles as well as upon the ocean, and so " as to lay sound foundations, if possible, for the " practical art of foretelling weather. In order to " avoid the difficulties which had arisen from placing " an officer of distinguished scientific attainments " under civilians, who were far more ignorant of the " subject than himself, and who were, consequently, at " his mercy, and in order to give the office the benefit

T. H. Farrer, Esq.

10 July 1872.

“of the freshest and widest opinions of the scientific world, the management has been placed in the hands of an unpaid committee of scientific men appointed by the council of the Royal Society. This committee administer the annual grant according to their own discretion, making periodical reports of their doings. So far as experience yet goes, the result is, I believe, satisfactory. The gentlemen composing the committee have selected an efficient staff and give, themselves, much time and attention to the subject. But it is as yet too early to predicate complete success, nor do I mention the case as a precedent, but merely as an instance of a mode which has been adopted in one particular case to meet some of the questions and difficulties which your Commission has to consider in the aggregate. The case itself, indeed, is one which the Commission will, no doubt, report upon. It is, I should observe, as regards the administration, an unprecedented experiment to commit 10,000*l.* a year, without check or account, to the charge of an unpaid body; and there is the further anomaly, that there are other public moneys devoted to meteorology under a pre-existing and totally different organisation.” I would add to those observations that I think it is quite impossible that we can expect any gentlemen to go on permanently giving attention to the management of a business of that kind, which this committee could give, without payment and without a recognised position.

12,640. Have any applications been made to you which would tend to show that, by an increase in the grant, the value of the results might be considerably increased?—I have seen suggestions to that effect given by very eminent scientific persons before this Commission, and my attention has been particularly called to it, because that is, itself, the sort of question upon which the Government would wish for the best possible advice. It is very likely that this question may be raised, and that application may be made to the Board of Trade for an increased grant for those purposes. At present the Board of Trade would only be able to ask the council of the Royal Society, as before, whether they thought it should be done or not; but I think that it would be very well if there were some body to whom they would have a right of going to ask for advice upon such a point.

12,641. Are you aware whether the application with regard to meteorology from the Scottish Meteorological Society came before the Board of Trade?—Yes, I am aware of that. The answer made by the Treasury and by the Board of Trade, also, to the Scottish Meteorological Society was, that, having given a grant of 10,000*l.* a year to a committee appointed by the Royal Society for the purpose of undertaking investigations, not only in England, but throughout Great Britain, and in fact beyond Great Britain, it was impossible for the Government to give a further or additional grant to a separate body. But then, again, supposing that the Scottish Meteorological Society were doing something different from that which the committee of the Royal Society were doing, it would be very desirable that the question whether what they were doing deserved assistance or not, or in what way it should be done, should be referred to some body of acknowledged authority in the scientific world.

12,642. Have you formed any opinion as to whether further grant ought to be given by the Government to scientific research?—I can only give an opinion which is of very little value; but I think there can be no doubt whatever that there are numerous subjects, and always will be numerous subjects, in which private observers are unable to do what is wanted. For the older sciences you have had observatories established at the Government expense, for astronomy, and now, recently, for meteorology; and those cannot be the only sciences to which assistance ought to be given on the same principle.

12,643. Now we come to the question as to how such advice should be obtained by the Government to guide them in such cases as present themselves. Have you formed any opinion as to how a regular permanent council for scientific advice could best be constituted?—It is more easy to say what ought not to be done than what ought to be done. I do not think that such a body ought, as has been suggested here, to form part of a government office, or to be appointed by the Government, or to be dependent upon the Government. I am afraid that the effect of the creation of any such body would be to get a Government representative of each particular science, who would become a bureaucrat with respect to that particular science. I do not think that you would get the best men in that way, still less would you get the action upon that body of the opinion of the scientific world which is so desirable. I know that we all of us in public offices are apt to fall into ruts, and I think that any scientific man appointed, with a large salary, as a member of that council to represent a particular science would be very likely to fall into ruts too. He would be a very powerful man, for he would have the administration of large funds; for, of course, in a council of this sort, the men who have the knowledge of the particular subject would be the men who would practically administer the grant given for the purpose of that subject; and, in that case, you would run the risk of letting those men lead the scientific investigations of the country. At the same time, I do not think that the body ought to be unpaid, as the council of the Royal Society and the committees appointed by it now are. I do not think that you can rely upon getting regular or trustworthy service from an unpaid body. I think that scientific men deserve a great deal more encouragement in the way of payment than they get at present. The question then is, whether it is not possible to get outside the Government a body of this description. I give with great hesitation a suggestion upon a point upon which I really am scarcely competent to suggest anything, namely, whether you had not better make use of what you have at present, namely, the Royal Society or a committee of the Royal Society, rather than attempt to establish any new body. No new body that you could establish would have the prestige, reputation, and influence that the Royal Society has. That is a matter not to be created; it is a matter which has grown with centuries. You have also, in the Royal Society itself, a scientific public to whose opinion any council or committee appointed by it would or might be made amenable; and my suggestion would be, that you should endeavour to create some committee or body out of the Royal Society which should bear a fixed relation to the Government, which should meet regularly, and the members of which should be paid something, as the directors of a joint stock company are paid for their meetings, to whom the Government should have a right to refer, who should feel that they had, on the one hand, a duty towards the Government, and who, on the other hand, should be bound to make public all their proceedings, so that they would be responsible to the public scientific opinion of the country. That is the best suggestion that I can make, but, as I say, I am very ignorant upon the subject.

12,644. You would in fact leave the nomination of the council to the Royal Society?—Yes, I would leave it to the Royal Society.

12,645. (*Professor Huxley.*) Have you considered whether it would be desirable to make this body a large or a small one, or have you formed any opinion upon that point?—That is a matter of some difficulty, because the body ought to be large enough to represent all the branches of science with which the Government is likely to have any connexion, but, at the same time, of course, the larger you make it the more cumbrous it is.

12,646. Would you be disposed to give a body of this kind any initiative, that is to say, the Government, as I understand, would have the right of applying to them, but, *per contra*, would this body have the

T. H. Farrer, Esq.

10 July 1872.

right of applying to the Government?—In matters of scientific research, decidedly I think that they ought to suggest to the Government, and say to the Government, Here is a subject which requires funds to make experiments and to make researches. I think that that would be an important part of their functions. I do not think with Colonel Strange that they ought to interfere with the administration of the Government, unless they are asked to do so; but with regard to the furtherance of science itself, it would be one of of their most important functions to say to Government, Here is this subject or that subject which ought to be inquired into.

12,647. Take a concrete case, namely, that of the "Captain," the building of which, as you are aware, was a matter of considerable controversy between the Constructor of the Navy, at the time, and certain other persons, it being currently reported that the building of the "Captain" was forced upon the department by outside influence. Supposing that to have been the case, and supposing such a body as this to have existed, containing men, like Sir William Thomson, for example, who were highly competent to form an opinion upon such subjects, would you, under such circumstances, have thought it a fitting thing, or would you have given this body the power of doing such a thing, that is to say, of intervening and making an application or making a representation to the Government upon the question; suppose, for example, that this scientific council had clearly made up its mind that the principle of the construction of the "Captain" was thoroughly bad and wrong, and that the ship would capsize, would you think it part of their duty and give them the power of making a representation to the Admiralty?—No, I think not. I think that in such a case as that the responsibility rested with the Admiralty and the First Lord of the Admiralty, and this body should wait until he applied to them before giving him advice upon a practical subject of that kind.

12,648. However strong their opinion might be as to the faultiness of the construction of the "Captain," you would not even give them the power of making a representation?—No, I would not. There are numbers of ways in which an opinion of that sort can make itself known, through the House of Commons, through the press, and in different ways, and I think you must leave the responsibility for the conduct of the practical business of administration with the departments themselves.

12,649. Otherwise I presume that this scientific council would stand in considerable danger of becoming a sort of *imperium in imperio*?—I am quite sure that it would be at war with the offices, and that any representation of that sort volunteered by such a body would set up the backs of the officials, and would lead to nothing but mischief.

12,650. I gather that the particular case of the Royal Society to which you referred just now was not a happy intervention of men of science from without?—We thought on that occasion that the Royal Society was outstepping its proper limits, and we wrote them a letter to that effect, which I was very sorry to put my name to.

12,651. (*Dr. Sharpey.*) The Royal Society acted as any other independent body in the country might have done; they believed that the Government was not doing its duty with regard to the safety of the public in passenger ships, and the safety of the crews in commercial ships, in not taking some steps to secure a sufficient acquaintance with the deviation of the compasses on the part of the commercial marine?—The Board of Trade thought that the Royal Society would have been perfectly right in saying to the Government, Science has determined that there are such and such laws with respect to the deviation of compasses; here are those laws at your disposal. But, when the Royal Society went further, and said to the Board of Trade, It is your business to bring in a measure to require those laws to be compulsorily applied throughout the merchant service, the Board of Trade replied that that was their business, and not the business of the Royal Society.

12,652. It was not the business of the Royal Society more than of any other outside body, except that they were specially cognizant of the matter. The Royal Society, in that case, acted like any independent body in warning the Government of what they considered to be the duty of the Government with reference to the safety of the community; that was the point which they took up. There had been measures taken with reference to the Royal Navy, and it was thought to be the business of some department of the Government to take similar steps with regard to the commercial navy, especially as they professed to look after the safety of the public with regard to the strength of ships, the number of lifeboats, and the limitation of the number of passengers; and it was presumed that this was a question of a similar character. It remained eventually, of course, for the Board of Trade or the Government to consider whether it would be a wise step to take?—Perhaps the best thing that I can say about it, I am afraid, is, that the application was not very successful or very encouraging, as an example.

12,653. (*Professor Huxley.*) The practical point that I want to get at is this: some gentlemen have official experience, that is a matter of fact, quite apart from the right and wrong of the case, and no executive department would view any interference of that kind with other than considerable jealousy?—Certainly; I am sure of it.

12,654. (*Dr. Sharpey.*) Especially if it were a body sanctioned by the Government that was interfering?—Yes; quite so; that was given an official right to interfere.

12,655. That is very different from an independent body giving an opinion?—Quite so.

12,656. In such a case as that of the "Captain," the representations made to the Government from other quarters would very probably have led the Government to refer a question of that kind to such a consultative body?—Quite so. I can quite imagine that the First Lord of the Admiralty might find it a great relief to be able to refer to such a body.

12,657. It would be an answer to the representations made to him?—Quite so.

12,658. (*Professor Huxley.*) Have you ever considered the question of a certain difficulty which arises about the administration of some sufficient sum of money for the purposes contemplated by those who look to the development of scientific research; I mean that money which was to be placed in the hands of any body of that kind for the promotion of scientific inquiry would have to be a very considerably larger sum than that which is now given?—Certainly.

12,659. And that it might be a sum sufficiently large to admit of its application to the erection of buildings of the character required for the carrying out of particular kinds of investigation; for instance, I need hardly tell you that various kinds of physical inquiry cannot possibly be carried on in an ordinary house, but you want a building to be specially constructed for that purpose. Do you see any difficulty in the administration of the considerable sum that might be needed for those purposes by a body composed in the way that you are suggesting, without any member of the body, who is a financial officer, responsible to the Government?—I think if you have large buildings and establishments you must have some financial officer responsible to the Government, or you must make the head of the establishment himself the financial officer and responsible, but that difficulty has been met and dealt with at Greenwich and at Kew.

12,660. Do you think that the Treasury would be disposed to entrust a large sum of money to a body such as we are contemplating without having some person to whom they could look as the person into whose hands the money should go, and who should be responsible for it?—I can imagine that, in the first instance, the whole of this machinery must, in some

T. H. Farrer, Esq.

10 July 1872.

way or another, be connected with some department, and that there must be some minister who is capable of defending the vote in Parliament, and of stating what has been done. Then, I should think, there ought to be no great difficulty with a proper system of administering the money, so that there should be some person who should keep the accounts and be responsible to the minister for spending the money in the way in which this council or body directed it to be spent.

12,661. At present, with the comparatively small sum which is placed at the disposal of the Government Grant Committee, as I understand, all that takes place is this, that the money is placed in the hands of the Royal Society, and the Secretary or President of the Royal Society reports to the Government what has been expended, when asked for?—Yes. The meteorological grant is a still stronger case, because, there, 10,000*l.* a year is given to the Committee of the Royal Society, and both the Treasury and the Board of Trade expressly refuse to have anything to do with their accounts, but I doubt whether that system would be applicable where you had permanent establishments. There, I think, you must have some permanent officer keeping the accounts and responsible to the Government.

12,662. (*Dr. Sharpey.*) Probably the money might be voted as an estimate?—The money might be voted as an estimate, but then the question would be about the accounts.

12,663. Does the Meteorological Committee render any account to the Board of Trade?—The Meteorological Committee renders no account whatever to the Board of Trade. The only account rendered is a report, through the Board of Trade, to Parliament of what they have done. The Board of Trade do not know officially what salary they pay to any person, and they have no control over it whatever.

12,664. Does that appear in the Report of Parliament?—Yes.

12,665. (*Professor Huxley.*) Has the Meteorological Committee the power of disposing of this grant as it likes; that is to say, can the Meteorological Committee erect a meteorological observatory? I do not think that there is anything to prevent them from doing so, but the grant is only made from year to year, and if they diverted it from the objects which were contemplated on the formation of the committee, the grant would be stopped.

12,666. (*Chairman.*) I presume that some accounts are kept?—I presume that they keep their own accounts, but with that we have nothing to do.

12,667. (*Professor Huxley.*) Does the Audit Office not have the auditing of them?—No, in no way; the Treasury have absolutely refused to have anything to do with it. I can quite conceive that, for certain purposes, it would still be desirable to proceed upon that principle. Take the case of a particular subject of research; it would be exceedingly awkward that such a body as we are speaking of should be obliged to go to their ministerial chief or to the Treasury for the approval of every half a crown that they spent. They would say, We propose to spend 1,000*l.* on such and such a question; and I can quite conceive that it would be very desirable that they should be left perfectly uncontrolled in the disposal of that 1,000*l.*

12,668. (*Dr. Sharpey.*) It might be a matter that required immediate determination, and that would not allow time for all those steps to be taken of representation, and so on? Quite so; it might be a series of experiments made once for all, about which they would understand perfectly well, but about which the Government departments would know nothing whatever.

12,669. (*Chairman.*) Have you any suggestions to offer as to the application of the endowments, for instance, of the universities to purposes of scientific research?—I confess that I look with great jealousy on large applications of moneys out of the public Exchequer, for purposes of this kind, whilst there are those enormous endowments which are at present diverted from the purposes of learning and knowledge, and which would be able, by themselves, if they were properly applied, to do almost all that science requires.

12,670. Are you prepared to give the Commission any details as to how you think the university endowments could be better applied than they are at present for the promotion of science?—No; I am afraid that I have not gone sufficiently into it for that; I only speak generally.

12,671. Have you any suggestion to offer with respect to the carrying on of scientific inquiries and their practical administration?—It arises out of what I have been saying before. I cannot think that it would be a bad thing for men of the highest eminence in science to have so much practical business as would arise out of their being members of such a council as we have spoken of. Supposing the council had regular times of meeting, they would meet once a fortnight or once a week, or whatever it might be, and I should think that, in that way, the best men of science could be induced to join the council without its interfering with their more proper work, and that that connexion of business with science would be good both for them and for the practical departments of the Government. In saying this, I distinguish, of course, between such advice as I have spoken of and the conduct of any particular scientific investigation. Theirs is quite a different function; their business would only be to say what inquiry ought to be made, and the inquiry must, of course, be made by a person who devotes his whole time and attention to it, and for that he must be paid, but that, of course, is a totally different thing from the function of sitting upon this council and giving advice generally.

12,672. You would not contemplate that they would be able to undertake investigations?—No.

12,673. Have you formed any opinion as to whether it would be advisable to establish a separate department of the Government in relation to science?—I dislike very much the idea of establishing new departments of the Government. If it were possible that this business could be placed upon the Minister of Education, who is becoming more and more important, I think that would be much better than establishing a separate department for the purpose.

12,674. (*Professor Huxley.*) I apprehend that the practical interpretation of your view with respect to the endowments of the universities of Oxford and Cambridge is, that you would have no hesitation in applying some of the endowments which are now devoted to the encouragement of literature and theology to scientific purposes?—No hesitation whatever.

12,675. (*Professor Stokes.*) Are you of opinion that no part of the endowments of the universities is devoted to science or scientific instruction?—I am aware that latterly a good deal has been done in that way, but I think a good deal more might be done.

12,676. (*Professor Huxley.*) I understand you to have considered the subject from a practical point of view, and the body, the establishment of which we have been contemplating, taking the initiative in reference to the department of the Government, have you formed any opinion as to whether it should have the power of taking the initiative with respect to scientific inquiry, and whether it should be any part of its duty, for example, to work out particular lines of scientific investigation apart from such applications as might be made to it? I can conceive that a body of that kind, when once established, may either act exactly as the Government Grant Committee does now; that is to say, if application is made to it for means to pursue a certain line of inquiry, it may assent to the application or refuse it, but the Government Grant Committee at this time take no initiative. Would you think it desirable, supposing such a body as we have been talking of were appointed, that, in addition to its power of acceding to or refusing applications made to it by a person who wishes to pursue a particular line of inquiry, it should initiate inquiry? I think so certainly, that it ought to be part of its duty to consider what are the lines of

T. H. Farrer, Esq.

10 July 1872.

inquiry which deserve assistance, and to bring those to the notice of the Government.

12,677. (*Professor Stokes.*) What parts of the university endowments do you consider are not applied to purposes either of learning or of science?—I imagine that an exceedingly small part of the endowments of the colleges in the university to which I belong, namely, Oxford, are applied to purposes of learning or science. They are applied to the reward of young men who have passed a good examination, and who ought to be working hard in London and getting the dirt on their boots, but you give them fellowships and place them in luxury at a time of life when they ought not to be in luxury, and, so far as I am aware, little or nothing is done for science or learning by this part of the endowments. We shall know more about it when the Commission now sitting has reported, but I imagine that besides the fellowships of which I have spoken a large part of the income of the colleges is devoted to the improvement of livings, and I do not see that that has anything to do with the advancement of science or knowledge.

12,678. Are you of opinion that the fellowships do not do good, by enabling men, instead of going out into the bustle of life, to live in college and to devote themselves to original research?—My small experience at Oxford would lead me to think that, if that is their object, it is an object which has entirely failed. I do not believe that, speaking generally, the young fellows at Oxford devote themselves to original research.

12,679. (*Chairman.*) Is there any further information that you could give to the Commission which you think would be useful?—No; I am not aware of any.

The witness withdrew.

A. W. Williamson, Esq., Ph.D., F.R.S.

ALEXANDER W. WILLIAMSON, Esq., Ph.D., F.R.S., further examined.

12,680. (*Chairman.*) Have you any recommendations to make to the Commission as to the measures which appear to you desirable for the advancement of science in this country?—There are some recommendations which I would venture to make, but which, however, cannot be taken by themselves. I conceive that the particular measures which I could venture to recommend would produce good or bad effects according to the circumstances in which they were carried out. For instance, a great centralization of the administration of science is, I think, very desirable for many reasons, but it might be productive of great harm unless the arrangements were made with great care.

12,681. Supposing the arrangements were made as carefully as you think desirable, what measures would you be disposed to recommend?—I imagine that a Secretary of State may, perhaps, be appointed, whose special duty it would be to look after the administration of science and education generally. I suppose that would be one official, and I think that it would be advisable that there should be a scientific council, whose business it should be to arrange and report upon the evidence which might be laid before them respecting any questions which were pending, before those questions came to the minister; but the chief security which I should see against the evils arising out of such a system would be, not only the character of the men who would be selected from time to time to form such a council, but, even more than that, the kind of work which was allotted to them; and I think that perfect publicity ought to be given to every one of their reports, so that everyone could tell the evidence upon which the ministry decided each one of those questions. Although such publicity might, and no doubt would in some cases, be productive of a little inconvenience, I do venture to think that it would, upon the whole, be salutary, and really would be essential to the due development of any system for the true advancement of science. Then, amongst the actual things which I most anxiously wish to see for the sake of advancing science, the main thing of all is the dissemination of scientific knowledge, and if that alone were done, it is more than all the rest put together; but we want earnest and competent workers trained to a knowledge of what we have, and they would be sure to find the means of working, even if the Government were to discourage it ever so much, and things would get on splendidly; but, of course, I should be glad to see something more than that. But there is no doubt that the main thing now that is wanted is a system, by means of which the knowledge of facts which exist should be diffused amongst the young in proportion to their power of learning them, and of using them. I cannot help always putting that in my own mind as absolutely foremost amongst the things needed for the advancement of science. I conceive that, in the working of any general system, there are national resources for the advancement of science which ought to be utilised, and that such a department would take cognizance of all the institutions founded for the purpose of advancing science by teaching or by research, and they should (as was originally understood to be their intention) distribute the public money so as to produce the utmost usefulness among them, and give them more help in proportion to the evidence which they have afforded of usefully employing the help which they have received; in fact, somewhat in the same way in which it is done in Germany.

12,682. What public institutions are you specially contemplating?—I should contemplate the universities; and I should fancy that it would be proper to treat as a public institution, in this sense, every institution which is possessed of funds for the purpose in question, and which is directed without a view to profit by its managers, but is administered for the advancement of education and of science, and that it would be well to take cognizance of what they are doing from time to time, if they were willing to consent to furnish materials for such a report. There might possibly be some institutions which, for a while, would be unwilling to subject themselves to what they might consider the restraint of such a check, because publishing annually their doings would of course amount to some extent to a check; but I conceive that such difficulties would naturally disappear in the course of a short time; they would feel it their interest to make known what they were doing, and what they have been unable to do for want of further aid. But I should like that even private efforts should be assisted. For instance, if any public spirited individual who had to found a school of any kind or establishment for research, to carry out what he felt to be useful for some particular purpose, and if that is found by its results to be useful, and it was proved that the continuation of such efforts would be useful, I think that it would be desirable that the Government should supply funds to carry it on, so that people would feel an encouragement to making efforts if they saw a prospect that their useful undertakings would not die with them, like the Kew Observatory, which, at present, lacks the funds for some observations which have been carried on there on the sun's spots, and which are stopped now for want of funds. Among the special arrangements which I have felt to be very important for the promotion of science, is a close union between the teaching functions and the functions of investigation and research. At present there are many really very good teaching establishments for the higher science in which research is not carried on for want of arrangements for that purpose. The teachers are put in such a position as to be unable to do it; they have not the aids and appliances which are given elsewhere for such a purpose, and really their teaching is less efficient from that circumstance. I conceive that the best teacher

A. W. Williamson, Esq., Ph.D., F.R.S.

10 July 1872.

is really the most earnest student, and continues to be so as the model of a student; he is always working himself, and he ought to be kept in a position favourable to that, so that his better students would be led on to original work, and young men who otherwise would never get into research would from the example of their teacher be induced to do so. On the other hand, I think that even those investigators whose tastes give them the least inclination for teaching functions would probably be most useful if they were in a place where teaching is going on; they want assistants. One of our chief requirements in making researches is competent youths trained to the sort of work in which they wish to be aided, and that school is exactly the place where such materials are to be found. I do not think that either the elementary teaching or the high scientific work ought to be treated as distinct things, but rather as parts of one and the same kind of work; one is a very humble part, and the other is a much higher part, but they are really different parts of the same work. Then I do most anxiously wish that there were some means of aiding all intelligent and earnest youths who have learned well what they have had occasion to learn, and are desirous of learning more, to continue their studies and to improve themselves further. I believe that any money, however great a sum it might be, which should be spent carefully and frugally upon that, would be better laid out than any money which is now laid out by the State. The waste of wealth which is incurred in this country by leaving competent brains fallow and idle, and often doing mischief for want of training, is something which really I cannot look upon without sorrow and shame for the country. I fancy that such a system would probably be very much helped if once the plan of it were laid down by private efforts. In fact, from the humblest schools up to the very highest schools, I should wish that youths whose means did not allow them to continue their studies as much as they would wish to do, or as much as they were capable of doing, should have sufficient aid for that purpose, and I am sure that science would by such a measure as that be advanced incalculably. I am sure that such things as that would do more than anything else that I could name. In fact, I conceive that the best way in which the State can promote the advancement of science is to help, in a careful and frugal way, everyone who is doing useful work to the extent of his need of such help, in order to do more useful work, without any opinions of their own or any partiality whatever, but simply judged by the work which is being done. Of course, any absolute test of an examination test would be out of the question in such a matter. Of course, the higher sort of scientific work must be judged of by the reports of competent people regarding its general tenor; and it is not possible that you could supply a simple examination test to judge of whether we will say a leading mathematician is really writing good papers or not; it must be by the general opinion which establishes his influence.

12,683. Can you suggest any measure by which the State might be enabled to discover the individuals whom it would be right for it to assist?—That is a kind of work which I conceive might naturally be done by the scientific council, and that any and every such person or institution would be allowed to apply for help through the council, and that the facts which they bring forward, together with any other facts which the council may take occasion to collect, should be embodied in the form of a report, to which advice might or might not be appended. I do not think it essential that the council should draw a conclusion, but that they should arrange the evidence so as to prepare for a conclusion, and that then the minister should decide the matter.

12,684. I do not think you have yet told us how you would advise that the council itself should be appointed and what should be its constitution?—The idea that I had originally regarding the council was, that it might be a body consisting of many members elected by the scientific corporations in the kingdom. But if the council were to do well the work which they would have to do, it does seem inevitable that its members would need to devote the whole time to that work, and, moreover, that they would set to do it better after some time. Their work, like most other kinds of work, would have to be to some extent learned, so that if the members were sent to act upon this council for two or three years, whilst retaining other active duties, and they were then to leave the council, I think it is unlikely that they could really do justice to the work, and it seems, therefore, necessary that they should be permanent; I mean in the sense of giving a dozen or 15 years to it, or some such period, during the latter part of their life, I suppose it would be. In that case I suppose a much smaller number would be sufficient, perhaps five or six members, instead of 20 or 30, which might otherwise be considered desirable.

12,685. Would you wish to see the members nominated by the scientific societies or selected at the pleasure of the Crown?—I should be glad if, in their selection, there were some system of the same kind as that which I was endeavouring to describe just now with regard to other scientific questions, that some one body of men, some committee, were to give a report upon the comparative fitness of the various persons available for each appointment, and that an independent authority above that body were to decide with such report before them. How that could be carried out is, perhaps, a matter of some difficulty, whether it would be undesirable that such a body were to propose members to succeed those who go out from their own body; they ought not to nominate themselves to that extent. I think they would command more confidence if that were not done, but, perhaps, a certain number of the chief scientific societies might each of them send a member to form a committee, to advise upon the appointment of the members of the council.

12,686. If we had arrived at the constitution of such council, do you think that it would have a large amount of work to do, and constant work?—Yes.

12,687. Could you enumerate what you consider would be the principal duties of this council, supposing it to be established?—I should put the specific duty upon them of preparing a complete report of the national resources available for scientific instruction and research, according to the sense of the word public which I am just now describing it, namely, those which are available for that purpose, and not for the promotion of the profit of individuals; and then that such a report should be re-edited annually, so that one should be able, by referring to it, to know what the funds of the institutions are, and what they are doing respectively. I think that it would be of immense value that there should be one general source of information upon that point, and then I have no doubt they would be applied to for many improvements, which would be needed in those institutions; and they would have to investigate the question so brought before them or referred to them by the Secretary of State for that department. I should think it likely that it might be found desirable to refer to this council for advice in the selection of committees to investigate practical matters; for instance, the matter of gunnery, or other matters which are not matters of pure science, and that they would be able to recommend the choice of suitable persons for any work of that kind in which scientific principles would have to be applied to some practical purpose. In fact, the number of questions relating to science which come before the Government now, directly or indirectly, are, I suppose, considerable; and from what I have been able to learn of late on that matter, I should think that a good many people must be incidentally employed, to the extent of a great part of their time, by giving advice upon such matters.

12,688. You could hardly expect that the council would be itself able to give advice upon every question that would arise?—No, not questions of the application of science. I should make a distinction between

A. W. Williamson, Esq., Ph.D., F.R.S.

10 July 1872.

science and its applications. If it came to include its applications, it would include everything, and I think that you would destroy the usefulness of the council if you were to constitute it in such a manner as to attempt to include even the most important applications of science to industrial matters, or warlike matters, or things of that sort.

12,689. Are there any dangers which you apprehend might arise in the working of such a body?—The one danger which occurred to me first, and which I think ought to be carefully considered, is, as to its being an element of resistance to progress. I think that in the ordinary course of events any six men, however well selected, who had to decide upon questions of advancing science, would have so many unreasonable proposals brought before them, and so many which would appear impracticable, that they would get into the habit of saying no, and that it would be a rather rare exception that they would see occasion to say otherwise than no. In fact, to avoid that, it is one main reason that I venture to suggest that the peculiar character of the functions of the council is to prevent or diminish very greatly, as I conceive it would do, the risk of their becoming thus statical, and that they should not have to decide questions, but simply to bring the rays to a focus, as it were, so that they may be easily perceived by the one person who is to judge. And I think that for another reason it would be very desirable. Of course there would be some danger of their being looked upon as influential people, and the possibility of private influence being brought to bear upon them in the promotion of schemes which individuals might wish to promote. I think that they would work better and would command more confidence in the long run if they were not, as a rule, to give much of their own opinions, but rather limit themselves, as much as possible, to collecting and arranging the whole of the evidence, and not only the evidence which is offered to them, but collecting evidence which is not offered to them, and letting the evidence speak for itself; so that each of them would say, It does not depend upon me. I have simply got to report the facts; give me the facts. I think that that is the proper position for such men.

12,690. And you would leave it to the minister to decide ultimately?—Yes, to some authority, I suppose it must be a minister, with that report before him.

12,691. Would you not apprehend that the minister would frequently not think it necessary to get further advice when he had got this report, and, as a rule, he would scarcely be competent to form an opinion of much value?—If he had reason to believe that the report did not do justice to the facts of the case, that it either did not do justice to the evidence which was before the council, or did not include all the evidence which it might have included, then I should fancy that it might be most suitable if he were to send back the report to them, with a request to have it amended in such and such particulars. But still it ought to be open to him at last to decide on his own responsibility, either in the sense suggested apparently by the tenor of the report, or contrary to it, if he chooses to do so; only the public must see the report, and judge what the evidence was. I think that there would be less risk of actual abuses occurring in that way, and the persons concerned in the work would be in a position more favourable to improve their usefulness than in any other way that I can conceive.

12,692. You think that the action of the State for the advancement of science ought to promote the free and natural development of our existing capabilities?—Yes; and what I mean by that is that the principle which I conceive ought to regulate the action of the State is rather that of promoting a natural growth than of building up something known beforehand. I think that if matters are so arranged as to allow the forces which exist nationally to work favourably and well, science will be advanced enormously; in fact, there are certain laws not known, of course, at present to us, but which regulate the advancement of science; and I think that the measures taken by the State ought to be taken as by scientific observers, who only interfere within certain narrow careful limits, and not attempt to create out of their own head, but to observe what is growing and what is not growing, and what kind of aliment and support has been most useful and what other kind of aid has been least useful; in fact, to proceed experimentally upon the basis of observation, I do not conceive that any really great system of scientific instruction or scientific work could be the result of anything else than of slow gradual growth.

12,693. (*Professor Smith.*) Do you think it would be easy, with regard to the functions of the proposed council, to separate the questions of pure science which you would submit to it from the questions of the applications of science which you would propose to exclude?—I have no doubt that in some particular cases it might be difficult to draw the line of separation between science and its applications, but I do not fancy that that difficulty would be very serious or one of frequent occurrence. There is one case in which, perhaps, my suggestion would be apparently contrary to my principle; that is education as an application of certain scientific principles. That, I conceive, would naturally come under the functions of the council to advise upon; but in matters of engineering, or agriculture, or gunnery, or naval architecture I do not see any difficulty in drawing the line.

12,694. Then you would not propose that the Government, if it wanted advice upon such subjects, should go to the council of science in order to obtain it?—I conceive that the Government might with advantage go to the council of science in order to find the individuals most competent to advise them upon such a practical point; but I think that the Government ought not to expect advice on such matters from the council itself. I do not see how the council could include matters of that sort with the really important questions of science itself without losing their homogeneity and unity of action. That would include all human activity almost, for scientific principles can be applied to all kinds of doings.

12,695. Do you think that it might be a part of their duty to direct the Government where to obtain advice upon any practical applications of science?—Yes, I think that a matter in which the Government would probably find it advantageous to refer to them for advice as to the individuals best qualified for working out particular practical problems of the application of science.

12,696. (*Dr. Sharpey.*) A good deal of evidence has been offered to the Commission in favour of establishing and maintaining laboratories of research at the expense of the State, in order to give opportunities to original inquirers to carry on investigations. Have you formed any opinion of the expediency of such arrangements?—I think that to establish a laboratory for research only would be beginning at the club end, and would be decidedly inadvisable. I think that the main thing for research is to give to schools, and especially to the higher schools, proper facilities for it, and to develope them greatly. At the same time, it is quite possible that, in exceptional cases, research might with advantage be carried on in separate places; but I should always view with regret, as a waste of resources, the separation of that higher work of research from the more humble work of teaching, which naturally belongs to it. They help one another, and I think that each would lose from being separated from the other; still, in some cases, it might possibly be advisable.

12,697. (*Professor Stokes.*) I think you said that you thought it might be a duty of this council of which you spoke to select from the persons who applied for work those who are competent to undertake it?—To this extent only, that, supposing any particular post were vacant, and half a dozen men applied for it, I should conceive it desirable that the council should make a report of the evidence which

A. W. Williamson, Esq., Ph.D., F.R.S.

10 July 1872.

each of those gentlemen adduced of his fitness for the post. In fact, it would be analogous to that which has now to be done in another place by committees appointed for such purposes, but that they should actually conclude the report with a recommendation or not, according to circumstances. They should not be bound to make a recommendation, they should be bound to analyze and arrange the evidence, and be allowed to make a recommendation if they feel that they can safely do so; but the essential thing should be examining and arranging and scrutinizing the evidence, and collecting, if they see the means of doing so and the need of collecting further evidence, and they should make inquiries regarding the individuals in question. I conceive that in many cases that would be desirable, and even necessary.

12,698. Then I think I must have misunderstood you, in supposing that you referred to persons volunteering to do original work, and wishing to obtain the means of carrying out their researches, but you had in view only offices to be filled?—I was thinking of offices to be filled when I spoke of those reports. I conceive that if any individual who had begun some particular work wished for aid in carrying it on, the report of the council, if one be made respecting this application, would be referred to them alone, probably, unless they saw fit to say, This man is of such and such a fitness, but other people that we know would do this work still better. I conceive that it ought to be open to them to bring in other considerations, if they felt it desirable to do so, and even to give a little more information than was asked, in fact.

12,699. You had in view, I presume, work involving a considerable amount of scientific capacity on the part of the applicant, otherwise I do not see how the council would deal with the numerous cases which might arise from a population of some 30,000,000 or so?—I conceive that only those who have undergone some considerable scientific training would, as a rule, apply directly to the Government in relation to these matters, and that an application coming from some perfectly ignorant unqualified person would probably be met by the statement of the fact that he did not fulfil the preliminary conditions for undertaking such work.

12,700. (*Professor Huxley.*) Do you contemplate entrusting any such council as this which might be formed with the origination of scientific inquiry, or would you limit its functions to the encouragement of original investigators who might apply?—I think it would be difficult for the council to act properly at the same time as judges and as parties interested. It would be better, therefore, if they were to be occupied almost exclusively by reporting upon applications made to them rather than by initiating questions. If they want questions to be initiated, I conceive that they might privately speak to people who would bring it forward, and that the case would be considered by the whole body impartially upon its evidence. I think if they were to take the initiative, it would be very liable to lead to the kind of abuse which is, perhaps, most to be feared.

12,701. You contemplate that it should be, hereafter, the customary practice of the Government, when it requires advice upon scientific matters, to apply to this body?—Yes.

12,702. On the other hand, would you think it desirable to give such a body, if established, the right to intervene regarding the scientific questions with which any department of the Government may be dealing? To put a concrete case, supposing the case of the "Captain" to occur again, and supposing such a body as this to exist, would you think, supposing that body had arrived at the opinion that the "Captain" was a vessel unfit to go to sea, ought to have the power of making a representation to that effect to the Admiralty?—I should not be inclined to think that they ought to deal of their own initiative with such questions as that. I think they could not easily do so without incurring the responsibility for doing it fully. There ought to be persons whose duty it is to look after such matters, and then they ought to be bound to look after them fully, to see that nothing passes without due scrutiny, and if such a council were to scrutinize with due accuracy all the things to be done by the different Government departments in which scientific principles are applied, they would be inadequate to the task.

12,703. There would also be some danger, would there not, of their rendering the work of the administrative departments impossible?—Quite so; but, at the same time, if any outside person represented to them an opinion on a subject involving practical action to be taken, I conceive that it might be proper that they should make a report upon this matter to the minister.

12,704. (*Chairman.*) Are there any additions which you would like to make to your evidence upon points upon which you have not sufficiently brought out your views?—Nothing further at the present moment occurs to me.

The witness withdrew.

E. J. Reed, Esq., C.B.

EDWARD J. REED, Esq., C.B., examined.

12,705. (*Chairman.*) You held for some years the office of Chief Constructor of the Navy in the Admiralty?—Yes.

12,706. Have you formed any opinion as to how far it is desirable for the State to promote the development of science?—I think that there are many branches of science remaining undeveloped at present, the development of which would be of great advantage to the country. I base that opinion partly upon the experience which I acquired at the Admiralty, in which I continually found that great and important questions were undeveloped for the want of organization and of the means of developing them.

12,707. Could you give the Commission any instance of investigations which you would consider desirable and of importance?—There is one which I deem of very great importance. Mr. Froude in his evidence before the Commission stated that he had in hand a series of experiments for the Admiralty, having for their primary object the determination of the relations between form, speed, and resistance in ships, and, as he justly observed, this inquiry collaterally raises some other questions, but there is one subject related to that which Mr. Froude has under consideration, but which has not been developed at all yet, and it is one upon which very important financial questions hang; I refer to the dependence of the form of ships upon the weight of the materials composing their hulls. It will be obvious to the Commission that if you are going to build a ship for high speed of the thinnest steel, you can afford to prolong the ends of the vessel at either end, and give them extreme fineness in a manner and to a degree which would be preposterous, and I may even say disastrous, in the case of a ship which had to be built with very thickly-armoured sides. In this country the earlier ironclads were made of a form involving very long and fine lines, in fact a form analogous to that of mercantile steamships, and the consequence was that although in the "Minotaur" type of ship armour and backing equivalent only to that used in the first instance in the "Warrior" was employed, yet we got a ship 400 feet long, costing nearly half a million sterling. The impropriety of that course impressed itself upon my mind, and I believe it was more for that reason than for any other that I ventured to propose to the Admiralty a great change in that respect, and placed before them the design for the "Bellerophon" as an example of a vessel which should be as fast as those long ships, and more effectually armoured, and much more handy, carrying at least as efficient an armament, and yet should cost about 100,000*l.* less. That policy was sanctioned by his Grace the Duke of Somerset, the "Bellerophon" was built, and I believe long before she was finished the principle obtained so much favour that the idea of building another of the extremely long vessels never entered anybody's mind, and it was stated by the late First Lord of the Admiralty, Mr. Childers, in Parliament officially that by adopting that modification of form at least a million sterling had been saved to the country in the course of a very short time. But I wish to impress upon the Commission, if I may be allowed to do so, that that economy resulted from a mere tentative and limited application of a scientific principle, which has never been developed, and which the organization of the Admiralty furnishes no means for developing. I indicated the nature of this investigation in a paper laid before the Royal Society some two or three years ago, but as the solution of it involves high mathematics on the one hand, and elaborate experimental investigations upon the other, it has never been taken up and dealt with in any sufficient way.

12,708. Could you give the Commission other illustrations?—A second illustration which I should like to give is this: the present condition of the marine steam-engine and boiler is very unsatisfactory. It is unsatisfactory to such an extent that I believe if the manufacture of iron and steel were improved with reference to its use in the construction of engines and boilers, and if improved material were applied by improved methods, a saving of one half of the present weight would be attained, and when I say one half I know that I am speaking greatly within the limits which some persons who have thought very much about this question would be prepared to express. Of course, if that be so, if we are carrying about in our mercantile and other steamships twice the weight which is essential for the production of the power, that is so much taken off either from the further power and speed which might be obtained, or from the freightage and commercial value of the vessel. I may mention that in the manufacture of shafts, for instance, of the marine engine and of stern posts, and other large forgings for ships, the method of production is comparatively rude, and it very much needs development. I for one feel the necessity of great improvement in these respects, because I know that at the present moment the successful production of those enormous forgings rests a great deal more upon the skill of a workman than upon the application of any science whatever to them. So much has the subject been neglected, that, at this moment, I have the responsibility of seeing some very large forgings indeed made for certain ships, and the most effectual manner in which I can give effect to my responsibility is that of selecting the very best working smith that I can find, and putting him into the manufactory where those things are being made, for him to do the best that his experience enables him to do, in order to see them properly constructed. I believe that if a regular independent scientific investigation were applied to a manufacture of that nature, enormous advantage would at once result.

12,709. Are you acquainted with the mode in which the Board of Trade carry out their functions with regard to the examination of trading vessels and passenger steamships?—I know intimately the exact limits to which the Board of Trade pushes its examinations, and I am prepared to state that they merely see that existing methods are properly carried out, whereas what I venture to allege to the Commission is that those methods themselves are of the rudest kind, and that many operations of ship-building and marine engineering are of a kind which is susceptible of very great improvements in the event of independent scientific investigation being brought to bear upon them. For the information of the Commission, I would mention the single feature of shafting. Very little scientific investigation would show, I am sure, that the construction and carrying about in steam vessels, where of course it is of the utmost importance to have everything as light as possible, of enormous solid shafting involves a great loss, and yet it is absolutely universal, and, I believe, in fact I know, it is true that Sir Joseph Whitworth, by casting steel into hollow hoops and drawing them out into hollow shafts, is enabled to produce an article of far less weight and far greater strength than the ordinary marine engine shaft, but nobody ventures to adopt it, simply because the scientific ground upon which they ought to proceed is uncultivated. No one knows precisely the amount of advantage or disadvantage that you incur by making a shaft, subject to torsion, hollow under the circumstances of a marine engine. I am of opinion that the investigation of that one thing would result immediately in very great advantages, but there is no body, no organization at present existing, that I am aware of, whose duty it is to make those investigations.

12,710. Do you think that such investigations cannot be carried on without the intervention of the State?—I think it is almost impossible for them to be carried on without State intervention, and for this reason, that the only way to carry them on is by the co-operation of mathematical investigation and experiment. You can get many manufacturers who will make the experiment, and you can get many mathematicians who can make the calculation, but you are not able to make it the interest of the two to work together after the fashion, for instance, in which Mr. Hodgkinson and Sir William Fairbairn in other days did work together. It is well known that their joint investigations were very valuable, but they resulted in difficulties and almost in recriminations, because they were in the hands of private persons rather than in the hands of some responsible Government authority.

12,711. Have you considered how far it would be possible to establish a system which would lead to the combination of investigations with the scientific attainments which you think desirable?—My difficulty in answering that question lies in the fact that I am unable to form a sound opinion as to how far a department of the State can be constituted for the purpose of advising other departments. It is easy to see that a department of the State conducting such investigations as those that I have mentioned, could only have its best effect in influencing the action of the manufacturing departments of the State, if I may so speak, and if a department of the Government were contemplated as an advising department only, I believe it would be an impracticability. But it has been suggested to this Commission, I believe, or at any rate I have heard it suggested, that a scientific department might relieve certain existing departments of the State of some of the duties in connexion with science and art. If that were so, if a department of the State had positive executive duties to perform, and were to have the promotion of those independent inquiries and the giving of advice to other departments attached to it as a branch of its duty, and not as its primary duty, I am disposed to think that such a department might work exceedingly well.

12,712. Do you think that the other departments would be willing to defer to the opinion of this special department?—I should be afraid that they would be willing to defer a little too often, and that the risk of such a department would be in a branch like the Admiralty, for instance, refusing to do some of the things which it now does, without first referring to this independent department, and that I am afraid would be an obstruction to the executive officers of the Admiralty; and unless the department were exceedingly well worked, it might operate as a disadvantage on the whole.

12,713. If it were thought desirable to establish such a department, have you any suggestion to make as to its constitution, or as to the advice which it should have at its command?—I am strongly of opinion that such a department should be enabled to draw for advice and for assistance upon the officers of other departments, as an *ex officio* operation, frequently. I believe that if a certain number of gentlemen were

E. J. Reed, Esq., C.B.

10 July 1872.

nominated into a permanent council, and if the minister had always to rely upon that council for its action in any particular case that arose, that would speedily involve the department in difficulties, because on some occasions where the scientific officers of other branches had found their proposals not seconded or opposed by the independent branch of the scientific ministry of the Government, it would induce them to oppose and to obstruct the right action of other departments of the Government, and would lead in short to a conflict of departments. But I think that on many large questions it would be desirable for the ministry of science to call upon the other departments for advice. I will take the case of dealing with inventions; I think it would be a very great relief to the Admiralty, as an example, if the consideration of inventions for the improvement of ships could be transferred to another department altogether. When I entered office, they amounted to about 90 per week, and it took the whole time of one assistant constructor of the navy to dispose of them. Under such circumstances it sometimes happens that the desire of the office is to keep them moving rather than to deal effectually with them when they involve inquiry and investigation. On the other hand, if they were referred to an independent department of the Government, it would be most necessary, before that department acted in certain cases, that they should call in the construction branch, or one or two officers of it, to advise with them upon such effects of the adoption of a particular invention as would not occur to the one naval architect, for instance, who was upon the council of the ministry of science. I think it is very important that the right of calling in assistance from the other departments should be reserved, because otherwise you would have the ministry of science recommending a thing which, for reasons not obvious to its one member, would be impracticable within the Admiralty, and that would soon lead to conflicts, which are very undesirable in administrative work. On the other hand, if the minister of science with his council were to deal generally with inventions and were only to call in the assistance of the Admiralty staff when questions of moment arose, and when it seemed to him desirable, I think that the Admiralty Department would be relieved of a very heavy responsibility and a large amount of labour, and that the ministry of science would give a greater degree of [illegible] action than it is possible for the Executive Department of the Admiralty to give at present.

12,714. You have been referring, have you not, to a council constituted according to Colonel Strange's proposal?—Yes.

12,715. Do you think it would be desirable, if there were a council of that kind, to have one a permanent one and constituted in the way that Colonel Strange proposes, or would you like to see the council constituted on some other system?—I should prefer myself to see a much smaller council with a larger power, or [illegible] than Colonel Strange seems to contemplate.

12,716. (*Professor Smith.*) By a power of reference you mean that of obtaining advice [illegible]?—Yes.

12,717. (*Professor Huxley.*) Is there not a possible danger that the existence of such a body as this might tend to do away with the sense of responsibility on the part of the executive officer?—Not, I think, if it were understood that the advice of the executive officer would be taken. There is this, that I admit, that at present (and here I am speaking from my own experience) a chief constructor of the navy, for instance, who sees clearly and feels intensely the desirability of a certain improvement, knows exactly whom he has to persuade, and he knows the brunt of the battle that he has to fight in overcoming any resistance to his proposals, and it is much to be feared, I think, that with an independent department the First Lord of the Admiralty would constantly, instead of surrendering to the advice of his executive officer, appeal to the other department, and then the executive officer would have to do over again, under somewhat less advantageous circumstances, what he has already done in convincing the members of the Admiralty. I think that would be the certain result, but, on the other hand, I think that that is to be balanced by the advantages of this independent council; and I believe that on the whole an executive officer would feel that the service which he was connected with gained more benefit a great deal than it lost by the existence of an independent department, because it is not to be doubted that now-a-days the question of expenditure plays so prominent a part in the mode of dealing with all proposals, that you are under some disadvantage in dealing with a minister who is bound to expend some millions annually, and no less bound to limit his expenditure as much as possible, and if you could go to a department of the Government constituted for the purpose of ascertaining the desirability of such an expenditure as you contemplate, I think you would get greater support than you now do within the Admiralty. I might illustrate that by saying that if I were now at the Admiralty, I should never think of proposing, because I should know that it would be quite useless, an arrangement by which that question which I have mentioned to the Commission should be investigated to the bottom, but if there were a ministry of science, such as is under consideration here, I should most undoubtedly have proposed it as one of the most urgent things which they should consider.

12,718. (*Chairman.*) Do you think that the existence of such a council might have prevented the disaster with regard to the "Captain?"—I think it is so far possible, that I am not prepared to state to the contrary; but I think it right that the Commission should know that the loss of the "Captain" was in no degree in consequence of a want of scientific knowledge within the Admiralty. It was thoroughly well known there that ships with very low freeboards carrying a press of canvas would capsize; and I myself publicly stated in a lecture at the Society of Arts Rooms to the Institution of Naval Architects that such a ship would capsize, and showed the reasons why, the paper being a mere scientific exposition of principles; those investigations had been published, and were so extensively known, that I happen to be aware that when the description of the capsizing of the "Captain" was read, there were at least three noblemen, who had not been connected with the Admiralty at all, but who had derived their knowledge from reading my books, who said that the description of the catastrophe was singularly coincident with the description which I had given of what would happen in such case; therefore there was no want of knowledge that such a risk was run in such a vessel. The deficiency, if it had any relation to science at all, was simply that of getting proper weight attached to scientific investigations; I say this, not from any desire to reflect upon the Ministry only, for at the same time a naval officer who is now in a very responsible position indeed at the Admiralty told me that he sat in the room and heard my paper, and thought that it was merely pushing scientific considerations into a [illegible] to which they did not apply at all, that a sailor knew much better than I could possibly know, how much sail to put upon a ship; and so on. Therefore I say that what we require to secure the non-repetition of such a case is to increase the spread of science and education, particularly amongst those classes from whom we derive our administrators. Moreover it was known in Parliament, because it was made the subject of a debate, that the "Captain" was expressly to be built with one half of the side which we, the scientific advisers of the Admiralty, had pronounced essential to the perfect safety of such a vessel. Of course the object in the construction of the "Captain" was to put that question to the test, whether that advice was sound, or whether it was not mistaken. My case was that our advice could not be proved wrong; but the advocates on the other side were continually proved right, as they supposed, until the catastrophe came, because it was not a question

E. J. Reed, Esq., C.B.

10 July 1872.

of a certain initial stability which would show itself early. The "Captain" had all the initial stability and the stability up to certain angles that the "Monarch" had. It was only a question of weather and a question of attaining a certain large angle of inclination, and her stability failing then. Therefore, the experiments at sea rather confirmed those persons who distrusted the scientific investigation until the moment that the catastrophe occurred.

12,719. (*Professor Huxley.*) It was simply, I presume, because they could not understand the scientific elements of the question?—I presume so.

12,720. Do you think that if the scientific council had existed at the time, and its advice had been given, supposing it had been founded upon true principles, as we must assume that it would be, it might have had sufficient weight to prevent the catastrophe happening?—Yes. That is a reason why I believe that such a department might possibly have rendered service in that case. I believe that had a recognised department of science existed, I should have appealed to it long before the "Captain" was lost, because there were personal controversies, extending over many months, in which I had to express my strong conviction that the "Captain's" efficiency and success ought not to be assumed, until it had been placed beyond all question; whereas there were persons in responsible positions who assumed that the all but universal favour with which she was viewed before she was tried was conclusive on the subject, and I do believe that that is a case in which I could and should have appealed to a scientific department for support against a pressure to which so many persons were yielding.

12,721. What is your opinion as to the establishment of a department solely for giving advice?—I should greatly doubt the success of a department established solely for the purpose of advising the other departments; but I think if a department of science could be formed and charged with many of the positive duties in the interest of science which other departments now perform, and with the giving of advice as a collateral duty, then such a department would stand and would be of great advantage to the country. My view is rather in favour of the Minister for Science and Art taking upon himself, for instance, the charge of all our artistic, scientific, and other collections, and the administration of all that fairly falls within the duties of science and art in this country under the responsibility of a minister devoted to that work.

12,722. (*Professor Stokes.*) When you speak of a scientific council, am I to understand that that council would constitute the department which you also mentioned, or that it is something distinct from it, that is to say, a body of advisers?—I believe that the council should be, as I have already stated, a limited number of men appointed as a board of advisers to the minister, much after the fashion in which the present Board of Admiralty are advisers to the First Lord of the Admiralty, but with this exception, that the minister would be recognised in this case as having the sole responsibility to Parliament, whereas in the Admiralty I believe it has not been quite settled whether the minister has or has not the sole responsibility. And in addition to this board or council there would be other individuals composing the executive branches of the department, the same as in any other department of the State.

12,723. Would you contemplate that the whole of the time of the members of this council would be likely to be occupied in that work?—I think not the whole of their time. I do not believe that any salary that you can attach to the office would secure the highest scientific advice and the whole of the time of the highest scientific persons. I think that is quite impossible. I believe that in some document of Colonel Strange's he proposes a salary of 1,500*l.* a year to certain members of this council. All I can say is, that if you touch any of the branches of active commercial life, a man cannot possibly surrender his association with them wholly for anything like that sum. It might be a very proper amount to pay a man for giving certain stated attendances and his advice during that time, but to expect him to devote his whole time to the Government for that amount is quite out of the question. That I believe to be one of the greatest mistakes in the existing department of the Admiralty. For instance, that the Chief Constructor of the Navy, a man whom the minister allowed in Parliament to be capable of saving or losing a million of money in a short period, should be receiving a salary of 900*l.* a year, as it was when I first went there, and 1,500*l.* a year, as it was when I left, seems to me quite out of the question, because it is well known that now-a-days the managers of private establishments receive very much larger incomes.

12,724. (*Professor Huxley.*) Do you contemplate that if such a council as you have been speaking of were established, it should be empowered to take the initiative in any advice that it may give to the departments of the Government, or that it should merely act when called upon?—I think that it should take the initiative also.

12,725. From your experience of the administration of a department of the Government, do not you think that that might give rise to a great deal of friction?—I think it might; but I think it would be an important part of the duty of the minister of the department to see that friction was avoided, by unofficial or semi-official communications, before formal action was taken, where it affected the conduct of another department. For instance, supposing you take the question of the manufacture of guns in the War Department, I think it would be impossible for a Minister of Science to exist long without feeling that in such an essentially mechanical operation as the construction of a gun it was very desirable to have mechanical advice. It is pretty well known that in every committee or body that is brought together for the purpose of deciding questions within the War Department on the construction of guns and projectiles, the committee is composed exclusively of military officers. I think that the Minister of Science whom I contemplate would feel that that was a subject for intervention, but I think also that he would make it, in the first case, such a subject for intervention as would induce the Minister for War to consent to the changes that would be proposed, as soon as they were suggested. On the other hand, if the Minister of Science were to act without regard to the feelings of the other departments, or if this council were to do so, it might easily produce very great friction indeed.

12,726. Do you contemplate, then, that this council of science shall be in the same relation to the minister as, we will say, the Indian Council is to the Secretary for India?—No; I think that this council should be entirely subordinated to the minister. I think that the minister should be the one responsible person, and that they should be solely his advisers, and in no degree have power except through him.

12,727. In the case of intervening or otherwise, the council would depend entirely upon the will or discretion of the minister for the time being?—I think so.

12,728. Then the bearing of my question is somewhat altered. I was contemplating a scientific council which should be perfectly independent of the minister. Would you give a body of that kind the power of intervening?—I would not have such a body. I think that the responsibility of the council must be exercised through the minister, and through him only; otherwise I believe that conflicts of departments would be certain.

12,729. (*Chairman.*) Is there anything further which you would wish to state to the Commission upon the subject of their inquiry?—I am not aware of anything further.

The witness withdrew.

Adjourned to to-morrow at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Thursday, 11th July 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

WILLIAM SHARPEY, ESQ., M.D., Sec. R.S. | GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.

The Rev. JOHN HEWITT JELLETT, B.D., examined.

Rev. J. H. Jellett, B.D.

11 July 1872.

12,729*a*. (*Chairman.*) I believe you were formerly Professor of Natural Philosophy in the University of Dublin, and are now Senior Lecturer?—Yes.

12,730. Will you have the goodness to describe the provision which is made in the University of Dublin for scientific instruction?—It may be divided into two parts, the scientific instruction which is provided for the ordinary students, and the scientific instruction which is provided for the honour students. The lectures are given partly by the tutors and partly by the professors. As far as possible we have endeavoured to confine the attention of the professors to the higher class of students, because, of course, it is supposed that they are the highest class of lecturers, and, therefore, we give them the highest class of students; but we have divided the lectures into two classes, "honour lectures" for the higher class of students, and "ordinary lectures" for the ordinary class of students. This provision runs through the lectures, in fact in all subjects, and in the case of the junior classes, where the number attending is large, we have divided the honours lectures themselves into two classes, giving the highest class to one set of lecturers, and the lower class, that is the class intermediate between the highest and the ordinary students, to another set of lecturers.

12,731. (*Professor Stokes.*) Does that division into two classes apply to the professorial or the tutorial lectures, or both?—Generally speaking only to the tutorial, for the reason that I have mentioned, namely, that the professor's attention is as far as possible concentrated upon the highest class of students.

12,732. (*Chairman.*) When you say that the lectures of the professors are confined, as a rule, to the higher class of students, does that apply to all the professors?—Whenever there are two lecturers in the same subject, one of whom is a professor and the other a non-professor, the higher class of students are always entrusted to the professor. There is scarcely any exception to that, excepting in a case where there may be only one lecturer in a special subject, and that a professor, and in that case the more ordinary class of students are allowed to attend.

12,733. Is there more than one professor in the same branches of study?—There are professors of allied branches, but there are not two professors distinctly of the same branch. For example, I may mention that we have two professors, one of whom is called the Professor of Natural Philosophy, and the other the Professor of Experimental Philosophy. The Professor of Natural Philosophy is really the Professor of Applied Mathematics, and in the paper which I have sent in I called him so, because it gives you more directly to understand what he really is. The Professor of Experimental Philosophy, as his name denotes, is the Professor of Experimental Philosophy in the true sense of the name. [*See* APPENDIX V.]

12,734. In what respect do the lectures of the professors differ from the lectures of the tutors?—In some respects they are like the lectures of the tutors delivered to a higher class of students, but they are more of the nature of prelection and less catechetical. Most of the lectures to the students with us in the College of Dublin combine the prelection with the catechetical instruction, that is to say, the lecturer gives his views and explanation to the students, but he also puts questions to them, so as to ascertain that they have taken in what he has taught them. The lecture of the professor has usually the first element more largely, and in some cases where the class is very large the lecture of the professor is entirely a prelection; the lecture of the tutor is never entirely a prelection, it is much more of a catechetical character than the lecture of the professor.

12,735. How far is it obligatory upon all the students to attend the several courses of lectures?—Generally speaking it is not obligatory, that is to say, a man can get a degree without attending lectures, so far as the degree in arts is concerned; but in order to obtain a degree in arts he must either pass eight examinations, or four examinations and four terms of lectures. It will be seen, therefore, that a student is allowed to substitute four terms of lectures, one in each year, for four examinations, but a man may attain a degree in arts without attending a lecture at all, but simply by passing examinations.

12,736. (*Dr. Sharpey.*) Must he have been resident at the University before he can take a degree in arts?—No, he need not be a resident, he need only come up at stated times for examination.

12,737. (*Chairman.*) How has the system worked of substituting attendance on lectures for examinations?—In each year the student is allowed to substitute one term of lectures for an examination; if this is done he is obliged to attend two sets of lectures, one in each of the subjects of science, and another in classics. There are certain modifications which I will explain afterwards if you should wish, but that is the general rule. He is allowed to substitute attendance on two courses of lectures for an examination, and at the end of the term a certificate is sent in to the senior lecturer that so many students have attended at least three fourths of the total number of lectures, and if he has attended three fourths of each of the two courses of lectures he then receives what we call credit for the term, and that term counts towards his degree in the same way as if he had passed an examination, with this restriction, that he can only do that once in the year; he must pass one examination in the year and one term of two courses of lectures, but he may attend examinations only without lectures, or he can replace four examinations by four terms of lectures, but he cannot go further than that, he cannot replace all the examinations by lectures.

12,738. Does the system work satisfactorily?—On the whole we consider that it has worked very satisfactorily, and we generally think that an attendance upon a term of lectures of the nature that our lectures are, that is to say, in a large degree catechetical, is a more satisfactory test of a man's knowledge, and not only is it a more satisfactory test, but it has communicated to him a greater amount of knowledge than by a simple preparation for an examination, no matter how good the examination may be. The fact is, that the man is really under examination for a much longer time, and a formal examination is necessarily a short process. Even if all the questions are of the most judicious kind it is a short process. I believe that most of us think that the attendance on a term of lectures is a more satisfactory test on the whole than simply passing an examination.

12,739. Do candidates for honours almost universally attend courses of lectures?—Almost universally; sometimes a country student will come up and obtain honours, but it is comparatively rare. The great majority of our candidates for honours attend lectures.

12,740. In defining the course appointed to be read by undergraduates, are the subjects of the lectures and

Rev. J. H. Jellett, B.D.

11 July 1872.

examinations strictly fixed?—No, not after the first two years. We go upon the principle that it is desirable that certain subjects should be learned by all the students in the early part of their course, and that then, after that is passed, towards the end of their course, during the last two years, you may allow them a certain amount of choice. Men are about that time fixing what professions they will take up, and we think that then they may have a certain amount of choice in the selection of the subjects which they are to present for examination, and accordingly we act upon that principle. For example, we allow a sophister, if he is so disposed, to drop classics altogether, and take up experimental science instead.

12,741. At what period do they become sophisters?—They become sophisters at the commencement of the third year. Our course comprises four years. It is not exactly four years in time, but there are altogether 12 terms, of which eight must be passed. I do not mean to say that four years must necessarily elapse between the time a man matriculates and the time that he takes his degree, because a man matriculating, say in the month of May, may by attending an examination in October save his first year in that way. So that the first year will practically only be from May till October, or, indeed, he may matriculate even later in the year; he may possibly take his degree in about three years from the time he matriculates, or even a little less than three years necessarily intervenes, but still it represents four academic years, the first of which is called the Junior Freshman, the second the Senior Freshman, the third the Junior Sophister, and the fourth the Senior Sophister.

12,742. (*Professor Stokes.*) Then one year is counted to the student by a sort of fiction?—It is not exactly a fiction, because he has to pass an examination. The first year may be saved by passing a single examination, provided you pass three examinations the next year. You must pass four in the two years, but you are allowed to pass one in the first year and three in the second year, and in that way, of course, in order to save the first year it is absolutely necessary only to matriculate and pass one examination.

12,743. (*Dr. Sharpey.*) Seeing that after the second year there is a choice left, so that classics, for instance, might be dispensed with, must classics have been gone through in the previous two years?—Yes.

12,744. (*Chairman.*) Will you name the subjects which are required from all students?—In the first two years there is no option allowed. In the first year every student must learn mathematics, and he must know some classics. Besides that in the second year he has to answer in logic, and in a certain amount of metaphysics and still also in classics. All those are compulsory. Then in the third year he must learn some mathematical physics; he must learn mechanics, and he must learn astronomy; but then he may dispense with classics in the third year and take up experimental science instead. In the fourth year he must answer in astronomy and in ethics; but as to the other subjects, viz., classics, experimental physics, and mathematical physics, he may dispense with any one of those he pleases and take up the other two.

12,745. Have those regulations been in force during a long period, or have they been recently introduced?—They have not been in force for a very long time, but they have been gradually enlarged, and more scope given to the students. I forget the exact date when the last regulation was introduced, but the whole thing has been introduced within, I think, about 20 years.

12,746. Have mathematical physics and experimental physics been introduced to a larger extent during the last few years than formerly?—Mathematical physics always existed. Experimental physics have been introduced to a very large extent, and provision made both for examination and teaching which did not exist in earlier times, or, when I was a student, at all.

12,747. During the fourth year the student may confine himself, may he not, if he pleases, entirely to experimental physics?—He must take up astronomy and ethics then. If a professional student, he has certain privileges which I shall explain now; but supposing he is not a professional student in any way, then of the remaining three courses which are optional courses, namely, experimental physics, mathematical physics, and classics, he may take up any two of them that he pleases, but the professional students are allowed certain privileges; that is to say, they are allowed to present one of those courses instead of two, and we find that they do avail themselves tolerably largely of that privilege. Engineering students, for example, medical students, and law students, all of these avail themselves pretty largely of the privilege which allows them only to present one set of optional subjects instead of two, in the fourth year.

12,748. (*Dr. Sharpey.*) During that time they are probably engaged in attending professional courses?—Yes, they are engaged in attending professional lectures.

12,749. (*Chairman.*) As a fact, what optional courses are most attended during the fourth year?—Mathematical physics and classics, I think, are about the same; experimental physics is growing in the number that attend, but it is not yet so large as the number who attend either of the other two courses.

12,750. Are there any inducements, so far as the number of students is concerned, to make them prefer one course rather than another?—As far as fellowships are concerned, if a student's object is to obtain a fellowship, mathematics and classics rank considerably above any other course. When I say mathematics, I mean both pure and applied mathematics taken together, so that if a student's object is to obtain a fellowship, he must, practically speaking, be either a good mathematician or a good classical scholar. I think that a man who is neither a good mathematician nor a good classical scholar would have a very slight chance indeed of obtaining a fellowship.

12,751. Experimental physics tell but little in the obtaining of a fellowship?—They tell, but they do not tell nearly so largely as either of the other two courses which I have mentioned.

12,752. There has been also some encouragement given to the study of natural science?—Yes, that has come in very recently; and Professor Macalister, who is here now, will be able to tell the Commission more about that than I can; I can only tell you the general rules that are adopted about it. A considerable number of years ago there was a tripos, as it is called in England, or, as we call it in Ireland, a moderatorship, instituted for the combination of experimental physics and natural science. This went on for a considerable time, and at last we found that the combination was too heavy, that it was too large a subject for a single tripos. Latterly we have divided the two, and we have now one tripos for experimental physics, as they are ordinarily called, and another for natural science. This has not been going on a sufficiently long time for us to know thoroughly how it will work, but we have no doubt that it will work exceedingly well.

12,753. (*Dr. Sharpey.*) Supposing that a candidate took a very high place, we will say the highest place in the tripos in natural science, what chance would he have of a fellowship?—You must understand that a fellowship is elected to not by the place that a man gets in the tripos, but by a separate independent examination. A man that took a high place in the experimental science tripos, unless he took a high place either in mathematics or classics, I do not think would have much chance of a fellowship. Our number of fellowships is small, and I do not think that he would have much chance of a fellowship under these circumstances.

12,754. Are all your fellows engaged in teaching?

Rev. J. H. Jellett, B.D.

11 July 1872.

—All our fellows are engaged in teaching. We have no fellowships of the nature that they have at Oxford and Cambridge, they are more of the nature of prizes. We take a man's life, and we require him to give his life to it.

12,755. (*Professor Stokes.*) Have the fellows much time for original research?—Yes, they have a good deal of leisure. The duties which they have to discharge are of a kind that harmonise with their pursuits, and which would not interfere very much with their making original research. Lecturing to the highest-class students I do not think interferes, and I hope it would be found in looking at the list that they have done something in the way of original research.

12,756. (*Chairman.*) You have, I believe, a good many scholarships as well as fellowships?—Yes, we have.

12,757. Are any of them given for eminence in experimental physics?—No.

12,758. Are they given solely for classics and mathematics?—I should say that there is no scholarship given purely for knowledge of experimental physics, but in the scholarship which is given for science experimental physics forms an optional course, a man may take it up, or he may take up logic and metaphysics, as an optional course.

12,759. (*Professor Stokes.*) Have you any means of taking account of original research in the case of a candidate for a fellowship; for instance, if a man has done something good in research, would that be an element in his favour?—No, there is no such provision. The thing I know has been talked of several times, but we never could see a practical way of carrying out such a thing.

12,760. Do you consider, as a general rule, that the most successful men in examinations are really the best men?—I think that the men who have done the most afterwards have always been very capable of answering at the examination; that is the best way we can have of judging of the matter. But I can quite conceive that a man might be able to answer well at an examination, and no doubt there have been instances of men who have been able to answer exceedingly well at an examination, who, notwithstanding, have not produced anything original afterwards; but I hardly know any case of a man who has afterwards distinguished himself for original work who did not also answer well at the examination.

12,761. Although they may not actually have obtained a fellowship?—It was the fellowship candidates that I was speaking of, comparing one fellowship candidate with another. Amongst the men who get in fellowships there are some men who distinguish themselves afterwards by original research, and there are some who do not. I have known cases of men who did not afterwards distinguish themselves, who yet have answered very well at the examination; but I do not at this moment remember any instance of the converse, that is to say, that a man who distinguished himself afterwards had answered badly at the examination.

12,762. He may have answered well at the examination, although he failed to get a fellowship?—Yes, he may, certainly. There have been many cases (I could mention a dozen) of men who answered well at the examination, and who have done well since, and yet who have failed to get fellowships.

12,763. (*Chairman.*) What provisions are there in the University of Dublin for the advancement of science?—The principal provisions, I think, may be divided into two classes; the one is the constitution of professorships. It was supposed that a professor, when you give him sufficient leisure, is much more likely to make original research, and to advance science, than another man; and the second is the foundation of laboratories and observatories, and general facilities to the workman to carry on his labour.

12,764. Have several new scientific professorships been founded during the last 40 years?—During the last 40 years there have been several new scientific professorships founded, and there have been several professorships a good deal changed; old professorships have been reorganized in such a way as that they have been very much improved. There have been several professorships founded in connexion with one of our schools, namely, the engineering school. And some of those, perhaps, I ought to have more strictly noticed in the first part of the inquiry, that is to say, the provisions made for teaching, because some of them are more markedly connected with teaching than with anything else. But at the same time there is this provision made for the advancement of science, the foundation of professorships, and we have on the whole found it to work very well.

12,765. Will you mention those professorships?—There are the professorships of civil engineering, applied chemistry, geology, mineralogy, zoology, and surgery.

12,766. What are the professorships that have been reorganized?—Those of pure and applied mathematics, experimental philosophy, the University anatomist, and astronomy; but the reorganization in the last branch has not been so great as it has been in some of the others. I may mention, with regard to the professorships of pure and applied mathematics, the change that was made with regard to them. Formerly each of them was a very small office, that is to say, it was an office paid a very low salary, I think some 50*l.* a year, and it was held sometimes by a senior fellow; at all events as a mere adjunct to the rest of his work. Then about the year 1830, I think it was, or 1832, the professorship of applied mathematics was placed on a new footing. The man who held it was required to give up his whole time to it, and if he was a fellow, and he was, generally speaking, a fellow, he was obliged to resign his pupils and nearly every other college office, and to devote his whole time to the professorship of applied mathematics. When I mention that the first professor elected under that system was the present Provost Lloyd, it will be seen that it has worked very successfully. The professorship of pure mathematics had been in somewhat similar circumstances before the year 1835, but in that year it was placed upon the same footing with the professorship of applied mathematics, and the late professor, McCullagh, was elected in the year 1835.

12,767. What has the University done in the way of building or improving observatories and laboratories?—I will take the laboratories first. We have built two new chemical laboratories within the course of the last 16 years. The second of those is in every respect the most important, for it is a laboratory for working chemists. Both are fitted to a considerable extent for working chemists, for students who wish to work at practical chemistry; but the second laboratory is the larger, and it accommodates nearly 60 students; in fact, in exact numbers, it accommodates 56. We have had that laboratory divided into cells, each of which accommodates two students, and each of which is provided with all the ordinary reagents for chemical work. We have found the students so anxious to take advantage of them, that at the very first opening of the laboratory it was filled at once. I think on the first day it opened we had the whole 56, and if we were able to build more cells I daresay we should be able to fill them. All kinds of chemical work are carried on there, but on that Mr. Leslie can say more than I can. I may mention with regard to the observatories that we have lately expended a considerable sum upon our astronomical observatory. We received the very handsome present of an object glass from Sir James South some years ago, and this has been fitted up as an equatorial. We expended upon it and upon the observatory to hold it, and some other things that we were establishing, about 2,000*l.* We have a Professor of Astronomy there, who takes constant observations, Professor Brünnow, and we find that the thing has worked exceedingly well.

12,768. Are all the observations published?—Yes, he has published some recently.

Rev. J. B. Jellett, B.D.

11 July 1872.

12,769. (*Dr. Sharpey.*) Does he give lectures ?—He does not give formal lectures, but it is the custom for the lecturers on those subjects in the College to take their classes out there sometimes, and then he explains to them the use of the instruments, and so forth.

12,770. Is the Director of the Observatory the Professor of Astronomy ?—Yes, he is the Professor of Astronomy.

12,771. (*Chairman.*) Have you also erected a new observatory for observations in meteorology ?—Yes, a magnetic observatory was erected about 30 years ago, or perhaps more, and a series of observations on magnetism and meteorology were carried on for a very long course of years, and the results of those observations have been published; and if the Commission will allow me I will hand them in—they are published in these volumes (*delivering in the same*).

12,772. Is this observatory under the charge of any professor ?—It is under the charge of the Professor of Experimental Philosophy for the time being; but the principal magnetic observations were made within the first 14 or 15 years of its existence.

12,773. Has it been thought advisable to discontinue to a certain extent those observations ?—It was thought that it was not necessary to carry them on with the same activity as formerly, because Dr. Lloyd thought that their work was nearly done, but they were carried on for a considerable time, and they will probably be resumed again ; but they were discontinued for some time after the first series of observations were made, which lasted for about 14 years I think.

12,774. Have any of the students, if they wish to do so, an opportunity of learning what is going on in this observatory ?—Yes, that is the principal use that is made of it at present. The Professor of Experimental Philosophy takes his class in there, and teaches them the use of the magnets, and the method of observing terrestrial magnetism, and so forth. I should mention that besides the laboratories which we have already constructed we are contemplating the building of a new general physical laboratory upon a large scale. We have all agreed that the thing would be a highly desirable thing to do, and it has become now simply a question of money.

12,775. It would be a somewhat costly undertaking, would it not ?—I suppose you could not rate it at less than 20,000*l.*, including a tolerable apparatus, at first. Apparatus is a thing which you go on continually adding to, but I should think that the first cost at starting could not be reckoned at less than 20,000*l.* with the fittings, and I am probably under the mark.

12,776. Has the University any surplus revenue available for such objects ?—All the revenues of the University are subject to the control of the Visitors, but all over and above its necessary expenditure may be expended upon any objects which the University thinks fit. Of course, if one year we have the money we can expend it upon an object of this kind.

12,777. How were the funds provided for the professorships which have been lately established ?—The professorships which have been lately established, indeed the professorships generally, are paid out of the fees which are paid by the students.

12,778. Have they no regular fixed salary attached to them ?—Most of the professors are paid entirely by fixed salaries, and some professors in the special schools, besides the fixed salaries, also receive fees, as, for instance, in the medical school ; but in general the professors are paid by fixed salaries, or, rather, I should say, they were paid until recently by fixed salaries ; but now it has been arranged that they shall receive a certain small fixed salary, and that they shall receive a sum varying with the number of students who are on the College books, so as to make them partake, to a certain extent, in the prosperity or adversity of the College, as the case may be.

12,779. Are the professorships ever held together with fellowships ?—Yes, but not with tutorships

12,780. Are all the fellows either professors or tutors ?—There are at present in existence certain fellows, that is to say, there are certain fellowships where the men are neither professors nor tutors. I should mention that several years ago, 30 years ago indeed, there was a class of fellows instituted of this kind. When a man first obtained a fellowship he was neither a professor nor a tutor, but simply a fellow ; then, as the tutors above him either died or became senior fellows or vacated their fellowships, those men succeeded gradually to the tutorships. That was not found to be a very satisfactory arrangement, and it is in process of being discontinued at present. There are now only two or three such fellowships in existence, that is to say, the fellowships are in existence, but it so happens that they are not filled, and the present men are all tutors, with the exception, I think, of the last.

12,781. (*Dr. Sharpey.*) Does the University of Dublin derive any pecuniary aid from the Government ?—No.

12,782. Does the University apply any of its income for the direct encouragement of original research ?—They are very liberal in aiding the publication of researches, that is to say, if you publish an original book and come to the University they are very liberal in paying a portion of your printer's bill for you, and sometimes they make grants, but that has not been very extensively the case, but sometimes they do make grants to assist men in original research.

12,783. Supposing a young physicist or a young chemist pointed out to the University authorities that there was a promising inquiry which he wished to undertake, would they have it in their power, or be willing, to assist him from the University funds ?—It would be rather unusual, but, at the same time, I have no doubt that, if they saw good reason to believe that the thing would be successful, or that it was a promising opening, they would give him assistance.

12,784. (*Chairman.*) How are the professors appointed ?—They are all elected by the Provost and the senior Fellows.

12,785. Are they always elected from amongst the Fellows of the University ?—Certainly not.

12,786. Have they not all taken their degree at the University of Dublin ?—Not necessarily ; for instance, the Professor of Astronomy was a Prussian, and Dr. Stokes, who is our Regius Professor of Physics, was not a graduate of the University of Dublin.

12,787. Is there anything you would like to say by way of addition to what you have now stated ?—Nothing more than that I would just press upon the Commission the desirability, if possible, of enabling us to construct a new physical laboratory. That is really the object which I am most anxious about at present.

12,788. Has the subject been for some time under the consideration of the University, and have they found some difficulty in providing the funds ?—Yes. I do not mean to say that we could not, by stripping ourselves, provide for it, but we have sundry other things which we think we ought to do, and which if we were to spend so large a sum as would be required for a laboratory we might not be able to do. There is another thing I should observe with regard to the nature of our property, that we are obliged to keep a considerable balance, and for this reason, our property consists very largely of the rents of estates ; those rents vary from time to time ; they are more of the nature of corn rents than of money rents ; that is to say, they vary from time to time with the prices of certain articles of provisions. Very lately, in consequence of the rise in those prices, the College rents were raised proportionately ; but what has happened one way may happen the other way, and we must make provision for the possibility that the rents may be reduced by the same kind of process that raised them. Therefore, it is necessary for us to keep a certain balance to prevent things coming to a stop, if such a casualty as that should happen.

Rev. J. H. Jellett, B.D.

11 July 1872.

12,789. A few years ago you expended a large sum of money on a new building, did you not?—We expended upon the new museum in the park more than 20,000*l.*, and then we expended in building, putting a new roof, and so forth, on our library, nearly 10,000*l.* more. We have expended between 40,000*l.* and 50,000*l.* within the last 20 years.

12,790. Were those funds provided from the surplus revenues which had accrued from time to time?—They were; there were certain funds that were specially called building funds, but those were not nearly enough, and the general revenues of the College had to be drawn on in order to construct the buildings of which I have spoken. I know that the architect's contract for the museum was 22,000*l.*, and then there were the fittings, and so forth, and I am sure that I am under the mark when I say 30,000*l.*

12,791. Are the Commission to understand that the University cannot provide funds for the promotion of a physical laboratory without trenching on the income of the Fellows?—They could do it without trenching on the income of the Fellows, but there are some other things which we also want to do. I will just mention one, for example, which we think we are bound to take in hand pretty soon, that is to say, we have a number of manuscripts of various kinds which we think we are bound to publish, and this would cost us a large sum, and we do not like absolutely to put it out of our power to do this.

12,792. (*Dr. Sharpey.*) Have you anything to state to the Commission with respect to the resources of the Royal Irish Academy; does it receive assistance from the Government?—The resources are of two kinds; there is a grant from the Government, partly general and partly special, and besides that there are the subscriptions of the members and certain funds—there is the fund called the Cunningham Fund, of which we are enabled to use the interest every year, and other funds that come from life compositions. A member is allowed, instead of paying an annual subscription, to pay a sum at once as a life composition, and then, of course, the interest of that is available for the general purposes of the Academy. Besides that we have a Government grant—the Government give us 500*l.* a year, and they give us the house in which we meet, and it is, generally speaking, kept in repair for us; it is under the Board of Works. Then they give us some special grants, and the one that this inquiry is most concerned with is this—they give us a special grant to be given to persons who are engaged in original scientific research. The way that that is done is this:—Supposing that any person is engaged or about engaging in some scientific research, he makes an accurate statement of what he intends to do, what experiments he intends to try, and the object. This is sent in to the Council of the Royal Irish Academy; the Council then refer this application on to the Committee of Science, and the Committee of Science consider whether the thing is likely to lead to good results, and give him the whole or a part of the money for which he has applied. It must be understood in this way, that we only grant money to the investigator for expenses out of pocket. We do not pay him for his time. We always suppose the investigator to give the time and labour of the subject, but we give him his expenses out of pocket, and then it is expected that a communication [illegible] of the results they shall be published through the Royal Irish Academy, which [illegible] grants [illegible] research. It has not been in existence for any great length of time, and, therefore, I am not able to speak very largely of the results.

12,793. May I ask how long it has been in existence?—It has been in existence, I think, for about five years. The idea was suggested in the Committee of the House of Commons of which Mr. Gregory was the chairman, and I recollect that in the report that they made to the House of Commons it was suggested that such a grant should be given. Then the grant was itself given some time after, but I think that it has been in operation about five years.

12,794. Is there a fixed sum annually voted?—Yes, 200*l.* a year.

12,795. Is that voted by Parliament to the Academy?—Yes, and we dispose of it in the way I have spoken of.

12,796. In fact, it is quite analogous to what is called the Government grant to the Royal Society here?—It is just the same kind of grant, and it is bestowed in the same way. Of course it is understood that if in any year we do not spend the 200*l.*, the balance goes back to the Government. They do not allow us to carry the 200*l.* along from one year to another.

12,797. (*Professor Stokes.*) Does it often happen that you have not occasion for the whole 200*l.*?—Very seldom.

12,798. (*Dr. Sharpey.*) Could you usefully employ more if you had it, as a general rule?—I think we have nearly enough as it is. Probably we could employ another 100*l.*, but certainly I do not think we could go beyond that; I should say that that is the outside that we could employ at present. It is very hard to say how much those things will expand, but at present I think this nearly covers our wants.

12,799. Do you make any return to Parliament of the distribution of the grant, or is it asked for?—It must go to the audit office. You always must pass the audit office, and we return so much to this person and so much to that person for such an object.

12,800. Is it made public in any way through your proceedings, for instance?—Yes, always. The Academy must always make it public. When the Council furnish their annual report to the Academy at the end of the academical year, they say, We have granted such and such sums, and this appears in the printed report of the proceedings of the Academy.

12,801. That 500*l.* which is given to the Academy, that you spoke of before, is for the purposes of the Academy itself, not for the purpose of giving grants to original inquirers?—No, that is not; that goes for the general expenses of the Academy, and the funds obtained from the members go for the general expenses of the Academy; one very large sum is for printing and publishing the proceedings and transactions of the Academy. I should add that for this latter purpose we have an annual grant of 200*l.* from Parliament.

12,802. Are you quite satisfied that that is an advisable mode of applying the public money towards the encouragement of original inquiry, as far as it goes?—I think it is.

12,803. Supposing that the Government of this country should ever undertake to give a much larger subsidy for scientific objects, have you considered in what way any funds for that purpose could be best administered?—I think that the establishment of laboratories and observatories is probably the way in which the public money could be best spent. I think that the public money that is spent in the way that I mention now, in aiding original research, is a very advantageous way of spending the public money; but just at present I do not see that there is an opening; I have not myself seen an opening for a very much larger sum than that which we have so expended at present.

12,804. (*Professor Stokes.*) Is the existence of the grant of 200*l.*, do you think, generally known in Ireland among the persons who would be likely to ask for it?—I am sure it is known by any persons who would be likely to take advantage of it.

12,805. (*Dr. Sharpey.*) Are you aware of the evidence that has been laid before this Commission by several gentlemen as to the expediency of establishing a consulting body to aid the Government in their intervention in matters of science?—I have heard of it.

12,806. Have you at all considered the advantages or disadvantages of such a proposal?—I have thought of it, and I think that such a consulting body as that probably would be a very considerable advantage, and I think it would be an advantage to scientific men themselves, if there were a sort of central means of

Rev. J. H. Jellett, B.D.

11 July 1872.

communication between them. At present I cannot but think that there is labour wasted sometimes in a number of institutions being engaged on the same thing at the same time, and that possibly if there were a central suggesting body of the kind I have alluded to it might be of very considerable utility.

12,807. Do you think that it would be needful that it should be a very large body, or a body of moderate size?—I do not think it should be a large body. My experience of large bodies is that they do not work. I do not think that a large body would be desirable, that is to say, even if the body itself were large they should have a small executive committee. It would be necessary, of course, in such a consultative body as that, that the various branches of science should be represented, and in that way you would require a considerable number, but I think that the actual executive body should not be large.

12,808. A case might occur of questions being submitted to such a consultative body which would require investigations to be undertaken by other persons?—Yes.

12,809. A question might arise which the consultative council might recommend should be submitted for investigation to such and such competent persons outside?—Yes, certainly, I think that it might be exceedingly useful in that way. Supposing a question of public interest turns up which involves some scientific research to be made, I think it would be highly desirable that there should be a body of this kind to whom the Government might say, Here is a question of public importance, and a general scientific investigation is necessary, how would you recommend it to be done?

12,810. Or proposals might be made to the Government upon scientific questions which at present they have no means of answering except by applying to private and irresponsible persons; would not it be better that they should have a responsible recognized body to whom they could apply in such cases?—I think it would. I think that the expenditure of public money in that way would be a great deal more regular than when it is done merely by the intervention of private individuals.

12,811. (*Professor Stokes.*) Do you not think that a tolerably small council might contain on it men who, although not acquainted perhaps themselves with all the branches and sub-branches of science, would know where to apply in case of any difficulty?—I think it is possible, in fact I am sure it is possible that there might; but in that way it appears to me that if the persons to whom they apply had no official connexion with the central council, their advice would be somewhat of the same irresponsible kind that now private individuals give to the Government.

12,812. Supposing that persons outside the council were invited to send in a report to the council, should a certain remuneration be made to them for their trouble?—Supposing there were no person in the council who was qualified to judge of it, the subject, for example, supposing the subject were a medical subject, and you had no medical man upon your council, I think that when you came to discuss the report you would find yourself in some difficulty. You would be almost entirely at the mercy of the irresponsible individual outside who had given the advice.

12,813. (*Dr. Sharpey.*) In other words, all branches of science should be represented by competent men, although it might happen that in particular lines of inquiry they would require assistance *ab extra*?—I think so.

12,814. Still they would be capable, would they not, of judging of the facts and opinions laid before them?—I think they ought; I think if you do not have something of that sort you are quite at the mercy of the person outside whom you had happened to consult.

12,815. (*Professor Stokes.*) My question contemplated the representation of all the main departments of science, but without perhaps necessarily representing every branch and division?—Then I daresay probably I should agree with you. Of course I could not carry on the subdivision to any very great length. For example, take the subject that I am myself most conversant with, applied mathematics. I do not want to have a representative of acoustics, or a representative of optics; one representative of applied mathematics would do.

12,816. As there would probably be numerous meetings of such a council, if one were established, and as it would be held, I presume, in London, and, therefore, the members of the council would probably be mainly composed of persons residing in London, or at no great distance from it, do you think that any jealousy would be felt in Ireland on that account in the establishment of a council?—I think if, in the first instance, there were not Irishmen put upon such council jealousy would be felt; but I think that if there were Irishmen put upon such a council, even where they were not able constantly to attend, they could be kept clearly *au courant*, in fact reports could be sent. Supposing you had an Irish medical man who had some special knowledge of medicine, if the council were consulted on any medical point it would be very easy to send the question to him to furnish a report upon, and you might leave it optional then with him to come to London to any meeting that he chose. We are rather a sensitive people, and I think it would be necessary to have some Irishmen upon such a council, if you had one.

12,817. Do you contemplate that a good deal of work could be done by reports from individual members rather than by meetings of the whole body?—I should say that most of the work would be done by reports possibly. No doubt the reports should be talked of, but, as far as I have observed, in all such cases it is the detailed report that decides the question. For example, in such a case as I mentioned about the allotting of the grant for scientific research, when an application comes in, some one member of the Committee of Science who knows the thing better than the rest is asked to take it away with him and consider it, and to tell the Committee what he thinks about it. I know that, as a practical matter, if that member reports that it is a desirable thing, it is done, and in the consideration of the question it is upon that detailed report that the decision rests.

12,818. (*Chairman.*) Are there any provincial philosophical and scientific societies in Ireland?—There is one in Belfast.

12,819. Does no scientific or philosophical society except the Royal Irish Academy receive assistance from the Government?—The Royal Dublin Society receives assistance from the Government.

12,820. Is the Royal Dublin Society considered a scientific society?—For practical science it is.

The witness withdrew.

The Rev. JOHN R. LESLIE, M.A., examined.

Rev. J. R. Leslie, M.A.

12,821. (*Chairman.*) I believe you have been formerly tutor at Trinity College, and are now Professor of Experimental Philosophy in the University of Dublin?—Yes.

12,822. What are the subjects of your lectures as professor?—Heat, electricity, magnetism, sound, and light.

12,823. Do the students begin attending your lectures in their third and fourth years?—The arts students do, but students in the professional schools of medicine and engineering sometimes attend during the first year.

12,824. Do the remarks which Professor Jellett made, with respect to the attendance on ectures counting in lieu of examinations, apply to your lectures?—Yes, that is to say, students obtain credit

Rev. J. R. Leslie, M.A.

11 July 1872.

partly by attending lectures on experimental physics, but not by attending physics exclusively.

12,825. Can you give the Commission an account of the museum of natural philosophy?—There is a collection of instruments intended to illustrate these subjects, to illustrate the lectures principally, but there are a good many instruments of precision.

12,826. Is it all that you require for the purposes of your lectures?—It has been largely added to within the last year or two years, and is being added to every day.

12,827. Have you a considerable number of students attending your lectures? Yes, of students in arts from 50 to 60, and of professional students about an equal number, or 130 in all; about 60 of them are medical students. An attendance on two terms of lectures in physics is required from all medical students, that is to say, the subjects of heat, electricity, and magnetism, as a preliminary to presenting themselves for the previous medical examination.

12,828. There is also, I believe, a museum of geology and mineralogy?—Yes.

12,829. Would you describe the collection in those museums as tolerably complete?—Very fairly so.

12,830. Is it chiefly of Irish geology and mineralogy?—It is chiefly with reference to Irish geology and mineralogy as being more at hand, but the collection is not intended to be at all local. There is a Geological Society in Ireland which brings local matters constantly under the notice of the Department.

12,831. Has the laboratory of practical chemistry only been completed within the last few years?—There has always been a laboratory of practical chemistry, but the number of students studying practical chemistry was limited. In order to afford greater facilities for medical students to learn practical chemistry more immediately connected with medicine, this new laboratory of which Mr. Jellett spoke was built and divided into compartments; it was more especially designed in the first instance for medical students, but it has since been used for others, particularly engineering students. There has been a third laboratory, which has served the uses of a subsidiary lecture room on a small scale in the museum building, which was built for the purpose of affording laboratories and museums about 20 years ago.

12,832. (*Dr. Sharpey.*) Is that the small working laboratory of which Mr. Jellett spoke?—Yes.

12,833. And the teaching laboratory is for a larger number of students?—Yes.

12,834. How long does a lesson last?—Three hours.

12,835. How many times a week?—Three times a week.

12,836. For what period of the year?—In the medical school, during what is known as the summer session from the 1st of April until the end of June.

12,837. (*Chairman.*) The University established about 30 years ago, did it not, a school for the students who were desirous to obtain the theoretical and practical instruction necessary for the profession of civil engineering?—Yes.

12,838. What is the nature of the instruction in this school?—It is partly theoretical and partly practical. The course comprises three years: the first is supposed to be mathematics, theoretical mechanics, and theoretical chemistry; the second year, practical mechanics, experimental physics, drawing, surveying, and practical inorganic chemistry and laboratory instruction; in the third year, practical engineering, and geology and mining.

12,839. Are the students at the close of their first year separated from the general body of the students for a special course?—Yes, but they must all be students in arts.

12,840. Must they go on studying in arts during those three years?—No; they must have passed an entrance examination in arts, but it is not necessary to rise from the junior to the second class, they need not take a degree, but the great majority do take a degree in arts, in fact the other is quite an exceptional case.

12,841. (*Dr. Sharpey.*) Do most of the medical students take a degree in arts? Yes, in order to get a medical degree. I may say that that is universally so now. There are some medical students who are not students in arts, but do not get any degree or license from the University of Dublin, they probably qualify for some other educational institution.

12,842. (*Chairman.*) Do the students who pass the final examination in civil engineering obtain a degree or a license?—Yes.

12,843. Is there a degree in engineering?—Yes, that is a recent change. Originally a diploma was given, and then a license from the University, and at the last meeting of the University senate it was determined to give a degree in engineering, called the bachelorship in engineering, they having changed the conditions of the license slightly. For instance, any student who has passed an examination for a license will be eligible for a degree in engineering, if he has previously obtained a degree in arts.

12,844. (*Dr. Sharpey.*) Where does he get his practical work?—Under some recognised engineer outside the College, but formerly no external practical work was required, further than what was given by the professor himself.

12,845. (*Professor Stokes.*) Does that practical work suffice for his study, so that when he gets his degree he has no occasion to go into a workshop and study under a civil engineer?—No, it was never intended to supersede that altogether, even under the old system; but prior to getting the license the University did not insist upon his having become a student with a recognised engineer. They only required attendance upon lectures and personal examinations; but under the new system, which has not come into work yet, and which has only passed within the last two months, it will be necessary for any candidate for the complete degree in engineering to have worked practically as a civil engineer for at least three years.

12,846. (*Chairman.*) You have stated the subjects of the three years' course required from candidates for the profession of engineering, do many students attend your lectures in experimental physics who are not intended for the profession of engineering?—Yes, a very small fraction of those who attend are intended for the profession, about one twelfth I should say of the total number.

12,847. Then the students who intend to become engineers are not very numerous?—Not compared with the medical school. For example, during the 30 years that it has been established, the average of licenses granted to engineers has been 10 yearly. Then a good many join who subsequently go away without getting a license, they get appointments by competitive examinations. For example, the junior class during the past year has amounted to 23, but probably the number of those who take licenses will not exceed one half that number.

12,848. (*Dr. Sharpey.*) Do they continue as engineers? They continue as engineers, and they get appointments abroad.

12,849. Do those men who go so far as to take a degree eventually become practical engineers?—Yes, with very few exceptions. Almost all of those who have got diplomas and licenses have got work of some sort or other, possibly in India.

12,850. (*Chairman.*) Which professor gives instruction in drawing and surveying?—The Professor of Engineering and his assistant; he has got an assistant who is supposed to superintend the drawing specially.

12,851. Do any students attend these courses who are not intending to become engineers?—I have known some, but it is the exception.

12,852. With respect to geology, are the students chiefly those who intend to follow the profession of engineering?—Some are; it is also an optional subject in the arts course, and it comes under the head of experimental physics in the fourth year.

Rev. J. R. Leslie, M.A.

11 July 1872.

The subjects in the fourth year are chemistry and geology, which may be substituted for classics.

12,853. Can honours be obtained in experimental physics and in geology?—Yes.

12,854. I think we heard from Mr. Jellett that those subjects do not tell much in the examination for fellowships?—No, they do not.

12,855. What is your opinion as to whether it would be desirable that any of the fellowships should be dependent upon eminent proficiency in those subjects?—I think that there would be a great difficulty, with the small number of fellowships in Trinity College, in departing from the recognised rule, that they should be made to depend principally upon either mathematics or classics.

12,856. Those subjects, however, are to a certain extent taken into consideration?—They are to a certain degree, but only to a very moderate degree; they are to a certain extent in the case, for instance, of scholarships. I do not know exactly whether Mr. Jellett expressed himself clearly as to the inducements offered.

12,857. Are we to understand that the scholarships are entirely for classics and mathematics?—The state of the case exactly is this, that for a mathematical scholarship a course of either metaphysics or experimental physics is necessary, but the weight attached to those subjects is about one sixth of the whole.

12,858. Do you consider that the engineering school has been a success?—I think that the engineering profession has been very much depressed within the last few years, they have been rather overstocked, but up to that time I think it was a very great success. A large number of men who have since been very much distinguished in the profession have obtained diplomas in the school.

12,859. Have any students come from England to avail themselves of the advantages of the engineering course they could obtain in the University of Dublin?—A very large number, they are not solely Irishmen.

12,860. I believe in all branches you have a good number of English students?—Yes.

12,861. Is there any museum attached to the engineering school?—Yes, the museum of natural philosophy and geology is supposed to be connected with it, but not exclusively, and also especially the museum of models, some of them being one sixth of the natural size, of important engineering structures that have been erected, for example, the more remarkable lattice bridges, or the Britannia Bridge, or great engineering works such as those, and a good many models illustrative of the progress of the steam engine and locomotives.

12,862. Do you consider this museum to be adequately provided with models?—It could be improved very much, but it is very fair, and it is being added to every year.

12,863. Is this museum provided solely from the ordinary funds of the University?—Yes.

12,864. (*Dr. Sharpey.*) Are you acquainted with the nature of the instruction given or intended to be given at the Indian Engineers' College at Cooper's Hill?—I have seen the prospectus of it.

12,865. Is it different from the course which is given in Trinity College, Dublin?—No, I do not think it is essentially different.

12,866. Do you think there is any advantage that a young man could gain in this new establishment in England that he could not equally enjoy in Trinity College, Dublin?—I do not think there is.

12,867. Many of your men have gone to India, have they not?—A great many.

12,868. And have they succeeded there as engineers?—Yes.

12,869. Have you ever heard any complaint of want of skill or sufficiency on the part of those young men who have gone out from your College?—No. I have heard complaints of the want of practical knowledge of engineering amongst students who obtain appointments by competitive examinations before they ever have been on practical works.

12,870. Have you at all considered the question of the necessity for the establishment of this new College in England?—I did consider it very carefully at the time when it was proposed.

12,871. What did you think of it?—I could see no reason for it. I thought that the existing educational institutions were quite able to supply the demand. I could not see how it would supply any information which would not have been available to them elsewhere, because I did not think it supplied the practical instruction which we never thought in the Trinity College engineering school could be given by the University, or a school connected with the College.

12,872. In fact you could only fit them for advantageously receiving that practical instruction?—Just so. In fact the idea which was entertained in Trinity College at that time was that the real improvement would be to modify the system somewhat in a manner analogous to that of the medical department, that those who have been appointed by competitive examination should then be able to go on work for a certain time, just as those who were successful in medicine in getting military medical appointments could go to Netley Hospital, which is analogous to practical work.

12,873. Do the medical officers in the public service go through the same general course of instruction as medical men intended for civil life?—Yes.

12,874. And they are subject to an examination on their general qualifications, and then learn the specialities of military service in the Netley Hospital as far as they can be taught?—Yes, that is subsequent to their having obtained their appointment by competitive examination.

12,875. But up to that point they go through the ordinary course as the ordinary medical students do?—Yes.

12,876. Do you think that some principle of that sort should have been adopted in reference to the engineers required for the public service?—Yes. I think that students who had passed the required competitive examination, and had given evidence of having passed through a regular course of instruction in engineering, should have been selected by competitive examination, and that after they were appointed they should have been sent out on practical works, not sent out to look at works in the way they are from some of the French engineering schools, which I believe has been found to be a very bad system, but actually to take part in the work. It has been always held in Trinity College school that any attempt to provide this class of information or instruction would not be successful, and that the students, unless actually responsible for the carrying out of practical work, would not take that interest and apply that attention to it which would be sufficient.

12,877. (*Chairman.*) Have competitive examinations worked as satisfactorily in the subject of civil engineering as in the more general branches of study?—I think they worked very satisfactorily under the old India system before the establishment of Cooper's Hill College.

12,878. Has that produced any disarrangement?—It certainly has, because one essential preliminary condition is that you must have resided for a certain time in Cooper's Hill College, or be placed at some relative disadvantage. For example, the moment Cooper's Hill College was founded, some men from the junior engineering class in Trinity College emigrated at once and came over to it, their original idea being to pass through the Trinity College school, and then to go in for the competitive examination. Of course that operates, to some extent, against all University and College engineering schools in th country.

12,879. (*Dr. Sharpey.*) And, perhaps, tends to narrow the sphere of choice?—Certainly, one would suppose so.

12,880. (*Chairman.*) What is the title of the degree that you confer in engineering?—It was originally

Rev. J. R. Leslie, M.A.

11 July 1872.

called a diploma and then a license. Now it is proposed to style it a bachelorship in engineering, analogous to the bachelorship in medicine, but to obtain this degree you must have a degree in arts.

12,881. Is it obtained very speedily after obtaining the degree in arts, or must there be a certain number of years intervening?—As a general rule I think students join in their second year, so that they are qualified to pass the final examination in the engineering school at the same time that they are qualified to pass the degree; but it is very rarely that they are both passed within six months, probably there would be a year's interval.

12,882. Would you wish to make any additions to your evidence?—The only observation that I would like to make would be with regard to the instruction in experimental science, which is peculiarly my business. As to the nature of the instruction, up to this time, it was given by lectures and demonstrations. What is intended to be conveyed by that is this—all students are required to attend the lectures, where the experiments are necessarily of a qualitative character, for an hour; suppose, then, those who wish for a more accurate knowledge would remain for an additional hour or, perhaps, two additional hours, and see quantitative experiments made or make them themselves. With regard to those last, a provision for accurate quantitative experiment does not exist, as far as I know, anywhere to the extent that it ought; and the proposal to erect a physical laboratory is intended, if the project can be carried out, to supply the necessary requirements. But what I would suggest would be, that the development of physics altogether depends upon the provision being made for accurate quantitative experiments, which may be to a great extent of the nature of original research.

12,883. What do you consider to be the principal object with which students study experimental physics, as they do not tell very materially upon the obtaining of fellowships?—The great mass of students do not look for a fellowship, and they are allowed to substitute experimental physics for classics. They must attend either the one or the other as ordinary art students. Some time ago the idea strictly was mathematics and classics. Experimental physics was introduced then as a substitute for classics as an optional subject. Some have a great taste for it, and those who are attending the two professional schools of medicine and engineering are bound to attend.

12,884. Is any career open to students of experimental physics except those who are studying for professional purposes?—I think not. The introduction of the subject has been practically speaking modern, and there is no great prospect of their deriving in any way any emolument from the study.

12,885. Is the number considerable who attend your lectures who do not do so with a view to enter into any profession?—I think the average number of arts students has been between 50 and 60 attending my lectures, and the number of professional students probably about as many more, that would make up about 120, and I should say probably there would be about 10 to 20 more who come merely for the purpose of just hearing what is to be said and seeing the experiments. I should say about 130 or 140 would be the number.

12,886. Is that annual or in the two years?—Every year. I have only had the experience of two years.

12,887. What is about the number of degrees annually conferred by the University?—About 175 degrees in arts.

12,888. That is apparently a very considerable proportion?—Yes, a very considerable proportion. You might fairly state that one fifth of the total number substitute physics for lectures in classics, and I think for the degree examination, for instance, about one fourth. [*See* APPENDIX V.]

The witness withdrew.

A. Macalister, Esq., M.B.

ALEXANDER MACALISTER, Esq., M.B., examined.

12,889. (*Chairman.*) You are Professor of Zoology in the University of Dublin, are you not?—I am.

12,890. Will you be so good as to describe to the Commission the provisions which are made for natural science teaching at Dublin?—There are four professors more or less directly connected with natural science teaching, a Professor of Geology, a Professor of Mineralogy, a Professor of Botany, and one of Zoology. Those professors give lectures, and each professor has under his care a museum, or in the case of the Professor of Botany a botanic garden and an herbarium.

12,891. Will you enumerate the courses delivered by the various professors?—The Professor of Geology delivers annually three courses of lectures; the first is on Physical Geology, the second and third are on Petrology and Paleontology. The Professor of Mineralogy gives one course of lectures, the Professor of Botany gives one course of demonstrations, and a course of lectures annually on structural and physiological botany, and the Professor of Zoology gives two courses of lectures annually. But I should add that it is in contemplation to increase the completeness of the natural science instruction; and for that purpose the natural science professors have submitted to the board a scheme of lectures, and a more complete system of natural science instruction.

12,892. Have you reason to believe that this scheme will be favourably entertained?—We have, because the proposal for a scheme originated with the board. The proposal came down to us, so that it, or a modification of it at least, we have reason to believe, will be received.

12,893. What encouragement exists to induce students to avail themselves of the opportunities of the natural science teaching in the University?—There are two; in the first place, a moderatorship in natural science which is open to any students that choose to go in for it, as a means of getting their degree. In it the students have an examination in Comparative Anatomy, Zoology, Botany, and Geology; and any students answering very creditably in those obtain a gold or silver medal, according to their style of answering. Then, in the second place, senior sophister students may take a course of Geology lectures and a course of Zoology lectures in the place of a course of classical lectures for keeping a term.

12,894. Are those subjects taken into consideration in the conferring of fellowships?—No, they are not, to any extent.

12,895. Is there a considerable number of students studying natural science in Dublin?—Not a very large number; the inducements are so few, that besides the moderatorship candidates and candidates for the Indian civil service, very few other students avail themselves of it. I might add that the Professor of Geology has the engineering students besides, and the Professor of Botany the medical students.

12,896. Are those subjects taken into consideration to any extent in the giving away of scholarships?—They are not. I might add, in connexion with that, that in the medical school, in the medical scholarship, Anatomy is considered along with other more technical medical subjects; but, in a scientific point of view, the natural sciences do not enter into any scholarship examinations.

12,897. Does the Professor of Anatomy give a course of lectures on comparative anatomy which is open to art students as well as the medical students?—Yes.

12,898. Is this course attended by any considerable number of arts students?—It is attended by all the moderatorship candidates, as the Professor of Anatomy is one of the examiners for the moderatorship, and by a few other arts students.

12,899. Are the examinations in natural science

A. Macalister Esq., M.B.

11 July 1872.

conducted by the professors of the various branches?—They are.

12,900. Do you never introduce foreign examiners, that is to say, persons not connected with the University?—Not in the natural sciences.

12,901. Is that the case in some of the other branches of study?—In some of the ordinary branches of instruction the Fellows examine.

12,902. But all the examiners are connected with the University?—Yes, all the examiners are connected with the University.

12,903. Is there a large number of medical students?—A very large number, over 200.

12,904. What is the course of teaching in the subject of medicine?—During the winter session, which lasts from the 1st of November till the 1st of April, each professor gives 56 lectures, and it is necessary for the students to attend 42 of those lectures, otherwise they do not get credit for attendance.

12,905. (*Dr. Sharpey.*) Is the professorship of Anatomy held for life?—No, it is a septennial appointment.

12,906. But the incumbent may be re-elected, may he not?—He may be re-elected.

12,907. In practice has that been so?—Yes; there were two cases in the old history of the College where a professor was not re-elected.

12,908. (*Professor Stokes.*) Are there many professorships to which the election is for a limited number of years?—Almost all the professorships, or a large number of them.

12,909. (*Dr. Sharpey.*) From what source does the Professor of Anatomy derive his emolument?—He has a fixed salary from the College in the first place, and he has besides a proportion of the fees for the lectures in Anatomy which he gives. The arts students are entitled to a course of Anatomy free, and the board of the College give the professor a certain sum to pay him for lecturing to those students free, and he also gets a proportion of the dissecting room fees. The professor is expected, or is supposed, to be surgeon to Sir Patrick Dun's Hospital, and he is paid a portion of the students' fees for attending. The present Professor of Anatomy is not connected with the Sir Patrick Dun's Hospital, but the professor is supposed to be connected with it.

12,910. Is it made a necessary condition of his appointment?—Yes, in the advertisement which has been recently issued for filling the Chair it is made a part of the duty.

12,911. The fact of his being appointed a professor would entitle him to hold the place in Sir Patrick Dun's Hospital?—Yes.

12,912. Is the professor a surgeon in practice?—Up to the present he has been, but in the recent advertisement which has been issued the postscriptum is that candidates not in practice will *cæteris paribus* have the preference.

12,913. What may the whole of the emoluments amount to?—About 1,200*l.* a year.

12,914. How many months in the year has he to do duty?—He has to do duty from the 1st of October, when the dissecting room opens, until the 1st of April, and then he has from the 1st of April to the 1st of June to deliver the lectures on Comparative Anatomy.

12,915. Has he to undertake much of the superintendence of the dissecting room?—Practically he has the entire responsibility of the dissecting room.

12,916. But he is assisted, is he not?—Yes, he is assisted by the University anatomist, and by demonstrators.

12,917. What is the position of the University anatomist?—The University anatomist receives a moiety of the profits on the dissecting room fees. His duty is to assist the Professor of Anatomy, and to take from him some of the routine work, but the professor is responsible for the entire anatomy teaching.

12,918. How are the demonstrators paid?—They are paid small sums from the funds of the medical school, but not a share of the fees.

12,919. Does the professor conduct the class examinations?—He is not supposed to do so.

12,920. But do any of his assistants do that work?—Not as a part of the regular teaching. In the examination for the degree in medicine, the professor and the University anatomist conduct the examination in anatomy.

12,921. How are the examinations for the degrees conducted?—By written questions and *vivâ voce.* The examination is divided into two parts, and in the first, the junior class examination, the students are expected to recognize the structures in the dissections.

12,922. So far as it is practicable?—Yes, so far as it is practicable.

12,923. Is there a special examination in Physiology for the degree?—There is an examination in what is called the Institutes of Medicine, which is the same as the principles of Physiology.

12,924. The same as it used to be in Edinburgh?—Yes.

12,925. That is conducted by the Professor of Institutes of Medicine?—Yes, that is conducted by Professor Law.

12,926. Is that done in the same way by written papers?—Yes, by written papers only.

12,927. Then there is no practical examination in that subject?—No practical examination in Physiology.

12,928. Is there a practical examination conducted either by the Professor of Anatomy or his assistant in Histology?—No, there is not.

12,929. Is the Professor of Anatomy also the Professor of Comparative Anatomy?—He lectures on Comparative Anatomy in the summer. He gives a distinct course, there is no summer human Anatomy course. The summer work is Comparative Anatomy.

12,930. Has he at his disposal a large museum?—He has a museum, but the space in which the specimens are exhibited is rather cramped. The museum consists of a very large number of specimens, but the space is very small.

12,931. If I remember rightly, the collection of comparative anatomy, once in Trinity College, belonging to the late Dr. Macartney, was purchased by some English institution?—Yes, it was, I believe.

12,932. Was it purchased by Cambridge?—I do not know; it has nothing to do with the present anatomical museum. It is, in fact, only of late years that the anatomical museum has attained very large proportions in point of size.

12,933. Is the Professor of Anatomy *ex officio* the conservator of that museum?—He is supposed to have the direction of the museum, but there is a special curator under him.

12,934. The curator is paid by the University, I suppose?—Yes, he is paid by the University.

12,935. Is the museum open to the students?—It is open to the students during the day during the session.

12,936. Is there a distinct museum of Zoology?—There is.

12,937. How is it maintained?—I have, as curator of the zoological museum, a grant of 100*l.* a year for the purchase of specimens and paying the ordinary working expenses of the museum.

12,938. Have you an assistant working under you?—I have one assistant.

12,939. Is that all the funds that are supplied to you?—That is all the funds that I have at my disposal applied for that purpose. In the case of a special collection being required, from time to time the board has granted a larger sum for special purposes, but 100*l.* is the ordinary sum. Some time ago a large quantity of money was expended by the board upon the purchase of an extensive shell collection, and things like that have occurred from time to time.

12,939*a*. Do you think that the zoological museum in the University of Dublin might derive any aid from the British Museum through the communication of duplicate specimens?—A very great deal of aid.

12,940. Have you considered the matter?—I have.

A. Macalister, Esq., M.B.

11 July 1872.

12,941. Have you ever communicated with any of the authorities of the British Museum with regard to it?—I have not, for this reason: the museum of the Dublin Society, which is also an extensive natural history museum, has, I believe, had some communication upon the subject, and the results have been unfavourable, and on that account I have not myself entered into any negotiations upon the matter.

12,942. Is the museum of the Dublin Society a large museum?—It is a large public museum of Zoology, Geology, and Ethnology.

12,943. Who has charge of it?—It is in charge of a special curator, Dr. Carte, who is an officer of the Dublin Society.

12,944. Is there any relation between the University and the Zoological Gardens in Dublin?—No public relation; but our Professor of Geology is the Secretary of the Zoological Gardens, and by that means we get a large number of specimens by purchase, but there is no direct connexion between the two.

12,945. The professor is not necessarily the secretary?—No, he is not; it happens to be so in this case.

12,946. When you obtain specimens from the Zoological Gardens, the University, I presume, has to pay for them?—Always.

12,947. How are these zoological gardens maintained?—By a grant from the Government of 500*l.* a year, and the subscriptions of the members of the society.

12,948. Is the ground which they occupy Government ground?—It is. It is in the Phœnix Park.

12,949. Is it obtained rent free from the Government?—I do not know, but I think it is.

12,950. And they have 500*l.* a year besides?—Yes.

12,951. Is that, with other ordinary sources of revenue, found quite adequate to maintain the gardens?—It is not. Occasionally, in special emergencies, the members have to supplement their own subscriptions considerably, as on the occasion of providing accommodation for the elephant that the Duke of Edinburgh lately presented to them, the members had to supplement their subscriptions very considerably.

12,952. (*Chairman.*) Is there any payment on entrance into the gardens?—Yes, there is, except to the members of the society.

12,953. (*Dr. Sharpey.*) Has the society a large number of members?—It has a very considerable number of members, but not nearly as many as we think we might have.

12,954. Is there any relation between the Royal Irish Academy and the University?—No relation. Professor Jellett is president of the Royal Irish Academy. The only scientific society in Dublin which is more or less directly connected with the University is the Geological Society of Ireland, and I might say that the geological museum in the College was formed, or, rather, the nucleus of it was given by the Geological Society about 1844, and the meetings of the Geological Society are held in the College. I may state that I am President of that society, and that at present it receives no assistance from the Government.

12,955. (*Chairman.*) Are the examinations in Zoology conducted on paper?—Partly on paper and partly by the recognition of specimens. As it is for a medal, the examination is made as strict as possible, and the students are expected to recognize specimens.

12,956. Do you find any difficulty in conducting competitive examinations in this branch of knowledge?—No, having a museum at my disposal with specimens, I do not.

12,957. I think we have been told that a large number of students make use of the chemical laboratory; to what extent is chemistry required, or is it one of the optional subjects for examinations for degrees?—Chemistry is one of the optional subjects; it may be taken up along with Experimental Physics for the ordinary degree, but it is absolutely necessary in the medical course for medical students.

12,958. But are students who take up Experimental Physics necessarily examined in Chemistry?—They are necessarily examined in Chemistry. For their degree examination they must show some knowledge in Chemistry.

12,959. Is the museum of the Royal Dublin Society available to any extent for University students?—Not more than to the general public. The zoological museum in the College is available to University students, and is very largely taken advantage of by them. All students preparing for the moderatorship invariably make it a part of their work to study the museum, and facilities are given for the examination of specimens.

12,960. Are there any other points upon which you would wish to make additions to your evidence?—I think not. [*See* APPENDIX V.]

The witness withdrew.

Adjourned to to-morrow at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Friday, 12th July 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

BERNHARD SAMUELSON, ESQ., M.P.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

Capt. D. Galton, C.B., F.R.S.

12 July 1872.

Captain DOUGLAS GALTON, C.B., F.R.S., examined.

12,961. (*Chairman.*) The position of the Government with regard to science is a subject to which I believe you have turned your attention?—Yes; I have necessarily turned my attention to it, because I have to look after a great many buildings which are connected with scientific objects, and I have, therefore, turned my attention to it much in the last two or three years.

12,962. Is that an important part of the duties of the office which you now hold?—Yes; under my charge there are the British Museum, the buildings at South Kensington, at the Kew Botanic Gardens, at the Botanic Gardens at Edinburgh, the Observatory at Edinburgh, the School of Mines, the College of Chemistry, the Jermyn Street Museum, and various other buildings.

12,963. Is it chiefly in relation to the buildings?—Yes; my duties chiefly relate to the buildings, but I have turned my attention to the subject for some time, having considered it some years ago, when Colonel Strange made a proposal at the British Association, which I took some trouble to investigate.

12,964. Have you considered that the subject may be looked at from different points of view, and in different aspects?—Perhaps my observations may be founded upon Colonel Strange's proposal, which was for a Commission to bring all the scientific experiments and all the science on behalf of the Government into

Capt.
D. Galton,
C.B., F.R.S.

12 July 1872.

one focus. I think that you should divide the subject between the science necessary for the ordinary occupations of the executive departments, and the sciences to which it is desirable to give aid, or rather the sciences which the Government is prepared to cultivate as the trustee for the education of the nation, as you may call it, or to assist in the cultivation of.

12,965. Will you first take up the question of what the Government requires for its own purposes?—What an executive department of the Government requires for its own purposes in the way of science must, I think, be left to the responsible executive head of the department, that is to say, to the persons who are held by Parliament responsible for the conduct of the several executive businesses, like the War Office, the Admiralty, the Board of Trade, and my own office, the Office of Works; you must leave to them the duty and responsibility of settling to what extent they will resort to scientific men, and whom they will resort to. I think I could give a curious instance which would illustrate what I mean. I was observing in some parliamentary papers the other day a correspondence between the Board of Trade and the Commissioners of Northern Lights, upon the subject of the appointment of an adviser upon lighthouses. The Board of Trade, upon the death or resignation of Faraday, appointed Professor Tyndall as their adviser, and wrote to the Commissioners of Northern Lights to inform them of it, and to direct them to employ Professor Tyndall in the same capacity, and they put a sum of money in the estimates for the Northern Lights Commissioners to pay Professor Tyndall to remunerate him. The Commissioners of Northern Lights wrote and said that they had a very high respect for Professor Tyndall, but they declined to be bound to employ any person other than the scientific persons whom they had already consulted, and with whom they were perfectly satisfied, and that if they were to remain responsible for the northern lights they must have the power of appointing their own adviser. That is just an instance of what I wish to point out.

12,966. Do you find that the departments often have any serious difficulty in getting advice on the scientific questions that present themselves?—I do not think that they have any difficulty. I do not know any case where they need have any difficulty. If you select scientific men and pay them properly you will always get good service out of them. I think very often the tendency has been to think that they can get scientific advice without paying for it. I think that, as a rule, our statesmen do not appreciate properly the value of scientific advice or scientific inquiry, and that they are very much fonder of experiments made upon a large scale with no defined system, than they are of experiments which have been brought out as the result of a carefully studied previous inquiry. I think that an enormous amount of money was wasted in the case of the inquiry into armour plates, both for ships and forts. In that case the Government appointed a partly scientific committee, but it was mixed up with other persons who were not scientific; and instead of commencing a series of experiments upon a small and clearly defined scale, from which they could have drawn conclusions for making their larger experiments, they began by firing at any plates that were offered to them which had no relation one to another, either in their relations to the guns or to the form of backing, or in any other way, and consequently it was difficult to draw useful calculations from them. There was an enormous amount of money spent upon those experiments, which, if a proper scheme had been drawn out and followed, would have been expended far more usefully; but the reason of that was the want of scientific appreciation in the persons at the head of the Government, who begged the committee at once to make great experiments instead of proceeding systematically with small ones to begin with.

12,967. Do you think that a remedy for that state of things would be provided by the establishment of a scientific council to advise the Government?—I think that the remedy for that sort of thing must be sought for in improving the education of our statesmen in science, because I think that you must get them to understand the meaning of what scientific inquiry is; and I hope by degrees, as our Universities increase in scientific training, that statesmen will improve in that respect. I have no doubt that if you had a scientific council, and if the executive heads of the Government referred to it, they would get very good advice; but I think you cannot relieve the responsible head of the executive department from the duty and position of settling whom he will consult upon those sort of questions for the purposes of the work for which he is himself responsible.

12,968. (*Dr. Sharpey.*) That question which you referred to about armour plating was a question which required to be solved by scientific experiments, was it not?—Yes.

12,969. And the heads of the administrative department to whom it fell to make those inquiries in that case were not merely applying as an executive body known principles, they required really to find out fresh scientific evidence?—Yes.

12,970. In such a case do not you think that if there had been a scientific advising council, the department could have referred the question to the council in the first instance, who would have advised such a course of experiments as you yourself would have pointed out; in the first instance, that there should have been experiments on a moderate scale with a given object, and in a certain order, with a certain correlation of one another, before they began those very expensive trials on a large scale, and that expense might have thus been saved?—I have no doubt that if they had referred it to a scientific committee in the first place, the committee would have probably advised the course which I was referring to, but what the War Office did do was to appoint a special committee for the purpose.

12,971. (*Chairman.*) Did they follow the advice of the committee?—They left the whole of the devising of the experiments to them, except that they told them that they wanted some big experiments.

12,972. (*Dr. Sharpey.*) Was it not rather a professional committee than a scientific committee?—There were upon it Dr. Percy, Mr. Pole, Sir William Fairbairn, and there were naval and military officers besides.

12,973. Of course large expense was incurred to the nation in making what one might almost call random experiments?—Yes, an enormous expense. A great part of that sum of money might have been spent infinitely more advantageously had there been a well-considered plan originally.

12,974. (*Professor Stokes.*) Does it not happen that questions frequently arise in the departments of the Government which it requires scientific knowledge to answer?—Yes, often.

12,975. Suppose there were two scientific men, A. and B., of whom A. was on the whole the more eminent, but B. happened to have attended more than A. to a particular branch of science, and suppose that the question which presented itself related to this branch, do you not think that a minister would be very apt to go for advice to A. rather than to B., on account of A.'s somewhat superior general reputation?—I think that would depend very much upon whom he consulted as to the person that he should select for his adviser.

12,976. Do you think it would be satisfactory to the public that the minister should consult somebody whose name he keeps in his pocket, rather than that he should consult a body of scientific men chosen for the express purpose?—I have no doubt that if you had a scientific commission sitting, composed of eminent persons, it would be a very useful thing for any minister, the head of an executive department, to consult that body as to the persons who he should employ in making any special investigations, or even, I think, he might possibly, if there were such a commission sitting, feel disposed to ask their opinion preliminary to the appointment

Capt. D. Galton, C.B., F.R.S.

12 July 1872.

of a special committee; but what I mean is, that I do not think that you could make it the absolute function of any commission, as proposed by Colonel Strange, apart from the executive head of the department, to be the sole adviser of the Government upon all scientific points connected with the details of the executive departments. But, I think, if you had a commission, the minister would frequently consult it, and would rather consult it than not, because, of course, when any minister wishes to get scientific advice, he always desires to get the best advice that he can. That has been my experience of the various departments that I have been in, and I have been in a good many.

12,977. I was not contemplating that the minister should be obliged to act according to the advice of a scientific council; but supposing that the whole responsibility of action were thrown upon him, and that he was at liberty, if he were prepared to take the responsibility upon him, to prefer other advice to that given by the council, do you not think that, with that full responsibility resting upon the minister, it would be very useful that he should be able to consult a scientific body chosen for that special purpose?—I think it would be very useful, and I think he would be very glad to have a scientific body to consult. I think an instance of the good results of having a body of a somewhat similar sort may have been seen in the Army Sanitary Commission, which was appointed for the purpose of considering questions relating to the sanitary condition of barracks and military hospitals; but the Indian Council consult it frequently upon a number of other questions, connected with the sanitary condition of India generally, apart from the sanitary condition of the barracks and hospitals of India. They take advantage of its existence to consult it.

12,978. You think, I presume, that a minister would feel his hands very much strengthened if he had the advice of such a council to act upon, without being bound to follow it?—I think that any minister would be very glad to have such a commission to go to, provided he was not absolutely bound to follow its advice without the power of exercising his own responsibility. I think he would require to exercise his own responsibility in the matter of the advice which he received.

12,979. (*Dr. Sharpey.*) Do you not think that there would be an important advantage in the fact that the advice of this consultative council would be given by a recognised public body, as compared with private advice received by the minister; their advice would probably be by reports that would be public, whereas, at present, the head of a department may apply to any private friend he likes in whom he has confidence, or any private scientific man, and act or not upon his advice, as he thinks fit, without the public knowing anything about it, or having any title to know whom he consulted?—I think that if the head of a department wished an inquiry into a special point, he would direct a letter to be addressed to such a council, if it existed, and would say, "Will you
" kindly advise me as to whom you would recommend
" that I should employ upon this subject, and what
" should be the line of inquiry which I should desire
" them to pursue." Then the answer from the council would of course be a document, which could be produced in Parliament if moved for, and that would be infinitely more satisfactory to the minister, as well as more satisfactory to the public, than the present system. I do not think that a minister ever cares to appoint any particular person for a scientific inquiry, except from an idea that he is the best person. I do not think that there is any question of patronage in the minister's mind, or that he has any guidance except common report and public opinion.

12,980. (*Professor Stokes.*) Do you think that giving advice to the Government on matters of science would constitute the chief and most important duty of such a council, if it were appointed?—I should not advocate the formation of such a council unless that council could be given duties other than those of a consultative nature. I do not believe in mere consultative councils. If a council is to be appointed, it must be a council for some other objects, and I think there is quite sufficient reason for the appointment of a scientific council or commission, or whatever you like to call it, for certain other purposes, and that when it was constituted for those other purposes, which are practically administrative purposes, the council might be advantageously consulted upon other subjects by the Government.

12,981. (*Chairman.*) How far do you consider that it is the duty of the Government to provide for the cultivation of science?—If it provides for education, it ought to provide for scientific education to some extent. All education, I think, should be framed with respect to what may be called the scientific training of the mind, and it has been decided by Parliament that the Government is to provide for education, therefore I do not know that the question is any longer a matter of opinion.

12,982. (*Dr. Sharpey.*) You refer to elementary education?—Yes. Elementary education is capable of giving a scientific training, if it is properly directed, quite as much as any other form, only I am afraid that our present system of education is not framed specially for the scientific training of the mind.

12,983. (*Chairman.*) Do you consider it necessary or desirable for the Government to do what private enterprise will do?—As a rule I have always been entirely opposed to the Government doing anything which can be done by private enterprise. I think that it is an enormous advantage to a nation to leave it to private enterprise as much as possible, that is *primâ facie* my starting point, but I think that now the principle has been settled by Parliament that the Government shall do certain things in respect of the nation which had formerly been left to private enterprise, and it is not, I think, so much a question for discussion as a fact.

12,984. You have pointed out that there are a very considerable number of institutions connected with science which are supported by the State; do you consider that there is sufficient system in the present arrangements?—I think that the institutions which are maintained by the State for scientific purposes are maintained upon no principle whatever with regard to their general administration. You have got the British Museum under Trustees, you have got South Kensington under the President of the Council, you have Kew under the Office of Works, you have the Botanic Gardens at Edinburgh, I think, under the Queen's Remembrancer. You have the Observatory at Edinburgh as part of the University of Edinburgh, and you have the Observatory at Greenwich under the Admiralty, besides several others. You have every possible variety of jurisdiction, and, consequently, it seems to me that you have a great waste of power, there is the School of Chemistry, and the School of Mines, and the Museum at Edinburgh, all under South Kensington Museum, and the Meteorological Department, which is partly under the Royal Society and partly under the Board of Trade. There is no possibility of getting any correlation between those different scientific bodies, and if you are to get proper unity of administration you must bring them all under one head, or to one focus. I should recommend placing them all under a scientific commission or council, and I should place that council probably under the Privy Council; but I should make it a body for administering all questions connected with all the scientific institutions, or all grants made by the Government for scientific purposes in the country, and I should give to this Council the same status with regard to its administration, or very much the same, that the Indian Council have; that is to say, that the parliamentary head of the department, if he differed from them in opinion as to their recommendations upon the scientific questions connected with those institutions, or any other that might be founded, should record his differences of opinion in a minute. Of course, as he would be finally responsible to Parliament, he must

Capt. D. Galton, C.B., F.R.S.

12 July 1872.

have the final power; but I should put the same check over him that is put over the Secretary of State for India, that he must record his differences of opinion, and his objections to their recommendations, or rather his reasons for not adopting the recommendations of this council, in a written minute which would be capable of being produced in Parliament if necessary. Of course the remuneration for those scientific gentlemen who would have to give a considerable part of their time to this council, ought to be of a sufficient nature.

12,985. Would you place the management of all the Government institutions connected with science in the hands of this council?—I should place the administration of it in the same way that the administration comes to the different Government departments now. The officers in charge of the British Museum would report to those gentlemen on all expenditure of money, on changes, and other matters of that sort. All their estimates would come up through this council, and all their expenditure would be sanctioned through it, and any questions arising in their administration, for instance, changes recommended, or new regulations, would be administered by this scientific council, instead of being administered by the separate heads of the departments who now administer them.

12,986. Are you satisfied that it would be advisable to remove the Royal Observatory of Greenwich, for instance, from the control of the Admiralty?—I have some doubts whether the Royal Observatory at Greenwich was not erected for executive purposes. It was originated partly for the creation of the Nautical Almanac, but I suppose it is not entirely for that. Without a good deal of consideration, one would not be prepared to say to what extent one would separate the observatory at Greenwich from the Admiralty; but I am disposed to think that the observatory at Greenwich might be very advantageously separated, and extended to a considerable degree in its functions. There are many more inquiries now connected with astronomy than are conducted there at the present time, and which might be very advantageously connected with such an observatory; but that is one of those points of detail which I do not wish to pledge myself upon as to my opinion.

12,987. Could you give the Commission any instances of mischief that, to your knowledge, has been occasioned by the want of system in the present arrangements?—I think that there is a great waste of force, as you get a duplication of functions; for instance, take the case of the British Museum and South Kensington, it seems to me that each of those departments, to some extent, overlaps the other; but South Kensington started a certain museum of what it calls "economic products," which appertain very much to what should be exhibited at Kew, if it is to be a complete botanic garden or department of that class of science. Similarly, at Kew, to some extent, it has collections of dried plants which trench upon the collections at the British Museum, or the British Museum collection trenches upon that of Kew. I do not wish to lay down any law as to which part should be made the focus of the whole, but I think it is undesirable for the Government to have two separate establishments forming the same collections. Of course it would be a question whether you should detach your botanical specimens from the British Museum to Kew, or whether you should bring those from Kew to the British Museum, and connect them with your fossil botany. That would be a question for a council of this sort to decide; but it is quite clear, I think, that it is a waste of force to have the duplication which at present prevails. There is no possible means of laying down any rule upon the subject by any proper authority unless you constitute a commission to lay down what are to be the limits of the spheres of the different museums. No doubt your Grace's Commission might lay down principles, but then those principles, unless they are carried into operation on some uniform system, would practically become a dead letter in time. I do not think that a temporary commission could sufficiently lay down principles which would control the management of those various departments advantageously for any long period of time. I think that the only way of getting those departments brought into a proper focus of administration is by placing them all under the same authority, and that a scientific authority.

12,988. Have you considered what would be the best mode of constituting such a council?—I should keep it to as limited a number as would represent sufficiently the different branches of science. I do not think that you could possibly have a smaller number than five or six. I think they would want a secretary, and, of course, they would have to meet tolerably frequently for the administration of these matters.

12,989. Would you leave the nomination of the council to the head of the department, the minister of state?—Yes; I think you must leave the nomination either to the minister of the department, or to the Prime Minister.

12,990. You would not give the scientific societies a voice in the matter?—I do not quite see how you could bring in that element. If it could be brought in advantageously, it might perhaps work well, but I have not considered that point at all.

12,991. Do you think that the minister would find any great difficulty in selecting a council of six or seven whose opinions would generally command confidence amongst men of science?—I think that he would be able to find six or seven very easily. He might, perhaps, have a difficulty in the selection from the number. There are some who would stand out pre-eminently at once, but of course there are more than six or seven whom you could name who would be very suitable.

12,992. Might not the difficulty be in picking out from all the scientific power of the nation six or seven whose opinions would especially command confidence?—I think there are a very large number of scientific men whose opinions would command confidence.

12,993. Do you think that the members of the council should hold their offices for life, or only for a limited term, say, of five or six or seven years?—The difficulty of giving the appointment for a limited term, is that you take a chemist, for instance, who might have been in some private practice, and would have probably to give up great part of his practice for the purpose of attending to this council. If you removed him from his position and he lost his remuneration, unless you gave him a retiring pension, he would have nothing to fall back upon. I think there are difficulties in that way.

12,994. You could not get the best men unless they might hold their offices for life, or were entitled to a retiring pension after a certain number of years?—I think not. I think, perhaps, the better plan would be to make them entitled to a retiring pension after a limited number of years.

12,995. Are you prepared to give any opinion as to the amount of salary which you think the members of the council ought to receive?—I am not. I think that you must offer them something between 500*l.* and 1,000*l.* a year, dependent upon the extent of time taken up.

12,996. Do you think that their duties would be tolerably constant?—I should think that if they had the administration of the whole of the scientific institutions, and the administration of all grants connected with science, their duties would be fairly constant.

12,997. Should you contemplate that it would be part of their duties to advise the Government as to the establishment of new institutions for the promotion of science?—Of course a council so composed would consider the whole question of science in the country, and they would, no doubt, in their discretion, make recommendations to the responsible minister as to the mode in which any extensions could be made, if they were found desirable. It would not be necessary to specify that as their duty, but they would necessarily undertake such a function in considering the question.

Capt.
D. Galton,
C.B., F.R.S.

12 July 1872.

12,998. In your view they would not be stepping beyond the limit of their duties in pointing out to the Government the necessity for establishing further institutions?—Not the least. I think it would necessarily form part of their functions.

12,999. Sir Henry Rawlinson, in his evidence before us a few days ago, pointed out that the Geographical Society frequently make applications to the Government to assist towards the expenses of expeditions for the promotion of geographical science, and that in some instances those applications are acceded to, and others are refused, apparently rather at hap-hazard, and without any system. Should you consider it to be part of the duty of the council to advise the Government with reference to such applications?—Entirely. I should think that all questions of expenditure of the public money for scientific purposes of that class should be referred to such a council and reported upon by them.

13,000. Whenever any application was made to the Government for grants for any purposes connected with science, you would contemplate that those applications would be referred to the council for their opinion?—Yes. Now it is perfectly notorious that the answers that the Government makes are entirely made hap-hazard, I think. They gave a grant of 2,000*l*. for the Eclipse Committee, and they have refused a smaller sum of money for enabling the calculations to be worked out upon certain tidal observations, without any reason at all. They have given no reason in the one case or the other. I think it depends entirely upon the amount of pressure that can be put upon individual persons at the Treasury.

13,001. (*Professor Stokes.*) The duties of the council that you have in contemplation are mainly administrative, are they not?—Yes.

13,002. Do you think that an administrative power and profound acquaintance with particular branches of science are to be found in conjunction?—I think you can find them.

13,003. Does it not seem to you that what generally happens is that one person goes out into the world, and takes part in administrative matters, while another studies in his laboratory or museum or library, as the case may be, and makes himself profoundly acquainted with a particular department of science, in which he would be specially qualified to give sound advice?—I think that most persons who have attained to a prominent position in science would be perfectly qualified to perform the advising duties of such a council as I have suggested.

13,004. I presume from the account which you have given of the duties which you contemplate being discharged by the council, that any scientific man who was appointed on the council would, so to speak, be killed as an original investigator; he would be able to do no more original work? His time would be occupied to a certain extent, but not entirely occupied, certainly not so much as that of Professor Graham, for instance, who administered the Mint, and was not prevented from continuing his experimental inquiries, although he was administering a department. It would not stop inquiry on their part. It would give them a comfortable means of livelihood, and enable some persons to pursue original investigation to a greater extent than they had hitherto done.

13,005. You pointed out, I understand, as a disadvantage of the present system, that in the cases of the herbaria at Kew, South Kensington, and the British Museum, there was a considerable amount of overlapping?—At South Kensington they have a museum of economic products which appears to be one which would very properly belong to a department like that of the Kew Botanical Gardens. The collection of dried plants at Kew and the collection of dried plants at the British Museum run side by side, as it were, to some extent, or are similar, and I think that one such collection would probably suffice if both departments were under the same administration.

13,006. An opinion has been expressed before us by more than one witness, that it was desirable that there should be collections of dried plants, both at Kew and in connexion with the collection at present in the British Museum, arranged according to different systems, the one being more complete as a collection for scientific botany, and the other to be used rather in connection with palæontology; if there are two collections arranged on different systems, must there not necessarily be a considerable amount of overlapping in the sense that the same kind of specimens will be found in both museums?—No doubt, and it would be the function of such a council to arrange for the limits of each class of collection.

13,007. Then I understand that you do not object to overlapping in that sense?—Not in that sense certainly, only overlapping in the sense of a similar collection in two places.

13,008. (*Professor Huxley.*) Mr. Carruthers, the Keeper of the botanical collection at the British Museum, in his evidence given before us, tells us first that there is no connexion between the two collections, the one at the British Museum and the other at Kew; secondly, that he does not see upon the face of it any reason for any connexion being established between the two collections; and thirdly, in reply to the question, "Do you think that the nation derives advantage "from possessing those two collections independent "of one another?" he says, "I believe the nation does." And then, at a subsequent part of his evidence, in reply to a question of mine, No. 7743, "Is "it your opinion that the two herbaria should be "equally perfect and equally complete without any "relation the one to the other?" Mr. Carruthers says, "It is my opinion that it is absolutely necessary for "the gardens at Kew to have a herbarium for naming "the plants, as Dr. Hooker clearly puts it. It is also "my distinct conviction that a herbarium for the "study of systematic botany has no connexion whatever with a botanical garden. It ought to be in a "position where it can be most freely consulted by all "students of botanical science, and there is sufficient "evidence that London is the best situation for such "a herbarium." In other words, the whole tenor of Mr. Carruthers' evidence, to which I am now referring, is to the effect that there ought to be two distinct herbaria, one at Kew and the other at the British Museum; and that neither institution could do its work properly without having such herbaria; and that also is the general tendency of Mr. Ball's evidence, and I think I may say of all the evidence upon this subject that we have had before us. The only matter in which the different witnesses differ is as to the proportion which the herbarium in one place should bear to the herbarium in the other; but upon the point of having two herbaria all the practical botanists whom we have consulted are unanimous; that being the case, do you think it is quite certain that a wise government managing these matters would not have admitted the duplication of those two establishments?—What I want is to have a scientific council which should be able to advise the Government as to what should be the limits of the spheres of the different departments, as, for instance, in the case of these herbaria, what should be the functions and the mode of classification in one herbarium as compared with the functions and mode of classification in the other. My argument is all adduced to show that the Government requires some scientific permanent council to advise it on those matters, and to lay down what shall be the functions.

13,009. I understand that you have a distinct opinion that Kew has nothing probably to do with an herbarium?—I did not say that Kew had nothing to do with an herbarium, but not with an herbarium of the same nature as that at the British Museum.

13,010. You, I know, are very much interested in science, and pay great attention to many parts of it; if you have chanced to pay attention to systematic botany or zoology, you would be aware that in the proper naming of a plant or an animal it is necessary to have a complete systematic collection of plants and animals, and that it is utterly impossible to undertake

Capt. D. Galton, C.B., F.R.S.

12 July 1872.

to name properly either animals or plants without having a complete systematic collection to refer to?—My argument is adduced merely to try to show that I think that the Government want scientific advice, and very constant advice upon that class of questions.

13,011. You do not wish to state to the Commission that in your judgment either the one institution or the other should be deprived of an herbarium, even although that herbarium must be, by the necessities of the case, a duplicate of the other, because two complete collections of plants cannot be different things, they must be duplicates?—They may be classified differently.

13,012. Your objection is not to the existence of a complete collection of plants at each place?—I do not want here to enter into discussion with Mr. Carruthers, Mr. Ball, or yourself, who have studied the thing much more than I have done; but my own *primâ facie* view was this, that there was a considerable loss of force by having two collections in different places entering into competition with each other in adding to their collections. I want the scientific department at Kew and the natural history department of the British Museum brought under one governing body.

13,013. Mr. Carruthers, in a document which he has signed, and which forms part of the Appendix of our published evidence, at page 46, makes this statement: "The expense of the two herbaria is very " small. I am unacquainted with the amount granted " for Kew herbarium, but it cannot greatly differ from " that required by the national herbarium, which " amounted for the financial year lately completed to " 1,767*l.*;" and then Mr. Carruthers, being particularly interested in the success and completeness of the herbarium at the British Museum, goes on to observe, " I know of no way in which the country can at once " advance the interests of science and encourage its " students at a smaller cost, and with more important " results, than by maintaining in their full efficiency " the two botanical collections at present existing." You see that Mr. Carruthers' statement is of an exceedingly strong character?—Yes.

13,014. I cite that more because if there were such a thing in science, it might be supposed that any rivalry that he might feel towards Kew would have rather led him to take another line; the present organisation of Kew, speaking broadly, dates from about the year 1840, does it not, when Sir William Hooker was appointed?—Yes, it dates from Sir William Hooker's appointment.

13,015. Are you acquainted with the Treasury letter defining the constitution of the gardens at that period?—No.

13,016. Then you are not aware that in that letter there is a distinct statement that the institution shall be to a large extent a purely scientific institution?—I have not seen the letter.

13,017–18. Speaking broadly, the whole constitution of Kew has not been altered, has it, since the time that Sir William Hooker was appointed there? So that anything that has been done there has been done in consequence of the original constitution of the place?—I really knew nothing about Kew till very lately.

13,019. The present Director has held his office only a few years, has he?—I think since 1865.

13,020. Anything which now exists in Kew, any herbarium, for example, existed there at the time when he was appointed?—I have no knowledge on that point.

13,021. As far as the herbarium is concerned, the great mass of it, that which was founded by Sir William Hooker, and to which additions were made by Mr. Bentham and others, could not be said in any sense to have been created by the present Director?—I have no knowledge.

13,022. Is it not, then, a matter of fact that whatever exists at Kew in the way of collections which may be duplicates of the British Museum collections, cannot be said to have been created by the present Director?—I cannot give you any information upon that subject, because I really do not know, but I take it exactly as you say it. My argument has no reference to that. I brought in Kew rather as an instance that a science council was required for the purpose of advising the Government as to bringing scientific institutions into one focus. What I want is for the British Museum to be brought into the same focus as Kew, South Kensington, the Botanical Gardens at Edinburgh, and other institutions.

13,023. It is not absolutely certain, under those circumstances, from the evidence of the botanists to which I have referred, especially of Mr. Carruthers, that the existence of those two collections, even although they were duplicates, should be a waste of public money, or a waste of anything?—It is not absolutely certain.

13,024. I apprehend that you would judge so from the evidence which I have just read from this competent botanist, testifying to the necessity of having two separate collections?—If it is admitted that it is necessary to have two separate collections, of course it is not a waste of public money to have them.

13,025. You would not yourself controvert the evidence that I have just put forward on the part of Mr. Ball or Mr. Carruthers?—Of course these are points which I should not be prepared to admit or to controvert without going into the question more fully. I do not controvert them, because, first of all, I have not read the evidence. I have only heard that part of it which you have read. Of course their evidence would be taken by the Commission on that point as much more valuable than any I should give. They are botanists and I am not.

13,026. You are aware that the Government, from time immemorial, has done a good deal for art and for literature; that is to say, it has kept up museums of pictures and sculpture, and it has kept up, at great cost, large public libraries. Do you approve of that action of the Government, or do you think that that ought to be left to private enterprise?—I accept that action of the Government as a fact.

13,027. May we not have the advantage of knowing whether you approve of the fact or not?—I think, at the present time, under all circumstances, and seeing that we have those collections, it is desirable to make them as perfect as we can.

13,028. Supposing that they had not existed, and that you had the power of establishing them in your hands, would you have established them, or not, as matter of public policy?—That is a question which is purely supposititious.

13,029. The purpose of my question is its bearing upon the further question as to what the Government ought to do with regard to abstract science, which stands on the same level as art and literature in relation to scientific pursuits?—Yes, I say that the country has accepted a certain amount of assistance to art and to literature, and has accepted the duty of giving a certain amount of assistance to science, both abstract and other science, and I take that as being established. I only point out that, having done so, it is most essential that it should administer its funds, in connexion with it, in a systematic manner, and I say that the same should be done with regard to art as I suggested should be done with regard to science, for it is equally not administered with any definite system of organisation.

13,030. When you say that those funds should be administered in a scientific manner, there are two senses in which it may be understood; the one is that the funds already existing may be applied to objects to which they are already applied in a more scientific manner than they are now, and the other is that the encouragement or the aid to science may itself be given in a more systematic manner. At present certain branches of science are encouraged and supported, while others, without any particular reason that you can see, are left entirely in the lurch. Would your opinion go merely to the better organisation of the assistance at present given to the particular branches of science on which it is bestowed, or to

Capt. D. Galton, C.B., F.R.S.

12 July 1872.

taking a broad view of science as a whole, and adding to the assistance already given assistance to other branches of science which seem to have an equal claim *à priori?*—I do not think, having put your administration of the existing scientific institutions upon a systematic basis, you could stop short at them. I think you would have to supplement them by giving assistance on a similar principle to other branches of science. I think that would be the necessary corollary of what ought to be done.

13,031. You would make the aid given to them systematic in both instances?—Yes, in both instances. I do not think there would be any ground for limiting it to the present amount. Inasmuch as the State has already admitted the principle, I should administer that principle upon a systematic basis, both with reference to its organisation and to the branches which it should assist; there is no doubt that that could be done.

13,032. Have you formed any opinion as to the propriety of establishing laboratories for original research?—I have not formed a conclusive opinion about it, because there are so many difficulties in the way; I see so many practical difficulties that I am not satisfied as to how it could be done. I cannot see my way to stating any scheme for it, and therefore I am unable to express an opinion in favour of it unless I see my way clearly as to how it was to work, and I have not yet seen that. I daresay that when I have read more of the evidence which has been given upon the subject I may be able to see my way better, but at the present time I do not see how such a system is to work.

13,033. (*Chairman.*) Have you referred to all the points on which you wish to give evidence?—Yes, I think so.

The witness withdrew.

W. De La Rue, Esq., D.C.L., F.R.S.

WARREN DE LA RUE, Esq., D.C.L., F.R.S., examined.

13,034. (*Chairman.*) You are a member of the Royal Society, and have been for many years a cultivator of science?—Yes.

13,035. Have you considered the question of how far science should receive recognition and encouragement from the State?—It has been a matter upon which I have reflected for a great number of years. It always appeared to me that science was not duly appreciated, and that scientific men were not properly recognised by the State. I am quite aware that in a measure science is aided, but not so efficiently as it might be.

13,036. Are there any measures which you think ought to be adopted with a view to the more effectual encouragement of science by the State?—I think that science ought to be recognized in the ministry by the appointment of a science minister, in order that all matters relating to science might come properly under the cognizance of the Government, and that whenever the Government sought the aid of scientific men it should be through the intervention of the science minister. It would be necessary that there should be a scientific man as secretary, and he ought to be aided by assistant secretaries in different departments of science, for example, in physical science generally and in natural science.

13,037. Would you have the assistance at his command entirely to consist of secretaries, or would you have something more in the shape of a board of advisers?—I imagine that the secretaries would be permanent officers, but there ought to be a board of advisers which should consist of men eminent in different departments of science. I can only speak as to those branches of science to which I have paid some attention, and I should put in the first category that there ought to be on the board a chemist of eminence, there ought also to be a physicist, an astronomer, a mathematician, particularly one who has paid attention to the application of mathematics to science, and an engineer or two engineers, one who has given attention to the construction of great works, such as railroads and bridges, that is to say, civil engineering, the other a mechanical engineer. I do not speak of a biologist or a physiologist, because other witnesses are much more competent to speak as to the necessity for such men than I am.

13,038. But do you think that all branches of science ought to be represented on the council?—Undoubtedly.

13,039. Might there not be a fear of its being necessary to make it very numerous, too numerous to do the work very satisfactorily?—I should hardly think so, because naturally only those members of the board would be summoned to confer with the minister when subject arose on which they were specially qualified to advise. There would not be a necessity for at all times summoning the whole of the board, but there should be a number of scientific men sufficiently remunerated to devote their time whenever called upon to do so to advise with the Minister of State. It would, however, be advantageous to have periodical meetings of the whole board.

13,040. Can you give the Commission any idea as to the number which you think it would probably be necessary to provide for?—About 10 or 12 men I imagine would sufficiently represent science.

13,041. You think that that would not be too great a number if all were to meet regularly?—I think it would be quite a workable committee. Occasionally it might be necessary for the committee to call in men who had specific knowledge of certain matters on which they might wish to be advised, but for a standing committee I think about 12 men would suffice.

13,042. Would you consider it to be the duty of such a committee to give advice on matters arising in the administration of the Government where the need of scientific advice was felt, and also to advise the Government as to what measures it would be right to take for the promotion of science generally in the country?—I think that these ought to be the functions of such a committee: in the first place all matters relating to science concerning the State ought to be referred to the committee, and all questions for the advancement of science would necessarily have to be considered by the committee, and reported on to the minister.

13,043. It has been pointed out to us that the separate departments of the State would be probably found to be unwilling to go beyond their own departments to take advice from a special department of the State; do you think that that indisposition would be found to exist; for instance, do you think that if the Admiralty wanted advice with respect to shipbuilding they would be unwilling to go to the minister of science and the scientific council for advice?—It appears to me that there would be certain subjects and scientific matters which would fall into a sort of routine after a certain time, and all questions relating thereto might very well be left to the department to which they belong; but there are certain cases of difficulty which arise from time to time on which, say, the Admiralty might need advice, and in such cases I should imagine that that department would only be too glad to refer the matters requiring special elucidation to such a board as would be thus constituted. For example, the question about the foundering of the "Captain" was one which would properly come before a permanent and responsible committee.

13,044. Do you think that a committee composed as you have suggested would be able to determine that matter in itself?—Possibly not, but they would act in a measure like a jury of highly educated men accustomed to deal with scientific evidence. At times they would undoubtedly, however, require to be assisted by experts in special casss brought under consideration, but they would be a much better tribunal than any that now exists.

W. De La Rue, Esq., D.C.L., F.R.S.

12 July 1872.

13,045. Have you formed any opinion as to what would be a proper remuneration for the members of the council?—That would depend in a great measure upon whether those gentlemen had other appointments; but it appears to me that it would not be a very large allowance if, in addition to their emoluments in other ways, they were to receive 800*l*. or 1,000*l*. a year. You cannot get learned men to devote their time and attention unless they are sufficiently remunerated, and it would be impolitic to have an under-paid board.

13,046. Do you think that their duties would involve very frequent meetings?—At first probably not, but I should think that the meetings would be rather numerous as the functions of the committee developed.

13,047. You would probably consider it advisable that their opinions should be on record on all questions submitted to them, and that a report should be drawn up?—Yes, a report should be drawn up and in many cases printed, so as to be available for the public.

13,048. Have you considered whether the appointment should be for life or otherwise?—I should say not for life.

13,049. Or for any fixed term of years?—Taking into consideration that care would be given to the selection of men who would not be wholly dependent on the pay attaching to the position, and that, on the other hand, it would require some time for them to become fully acquainted with their duties, it appears to me that if they were elected for five years, with the condition that they should be re-eligible, if willing to continue their services, that term would be sufficient to induce eminent men to serve on the board.

13,050. Would you leave the selection entirely to the minister, or would you give the scientific societies any voice or any right to recommend?—It would be desirable that certain societies should have a voice in the selection, of course leaving with the Government the final appointment; possibly they might advantageously recommend two men from whom the selection would be made.

13,051. Might there not be occasionally some difficulty in prevailing upon eminent men to abandon their own work if their appointments were only for a limited term?—That might present a difficulty in some cases, but if it were one of the conditions that those men were re-eligible, provided they desired to continue, I think that men of eminence would not be deterred from accepting office.

13,052. You think that there would be no difficulty in getting the services of the most eminent men of science in the country?—I do not anticipate that there would be any difficulty. Of course I have it in contemplation that if they accepted a seat at the advising council they would not relinquish any other position that they might already hold.

13,053. You do not consider that their duties on the council would be so onerous as to require the whole of their time?—I do not think so, but a great expenditure of their time would be required on some occasions.

13,054. Are you of opinion that any new institutions in the way of laboratories should be established by the State?—I hold it to be so important that chemistry should be extensively cultivated in England that I would strongly advocate that there should be a State laboratory. That State laboratory should undertake all the chemical work which the Government might require, but at the same time, according to the views which I hold, it ought to be such an establishment as could afford facilities to men who have completed their scientific education, and who might be desirous of continuing original investigations, in which space for working and instruments should be afforded them, and, moreover, if men were not in a position of fortune to continue their researches, in some cases materials and even money might be granted to them on the recommendation of the council. I may state that of my own knowledge I know that chemical science at present is not progressing in England in a satisfactory manner, that we do not make so many original researches as our continental neighbours, particularly the Germans, do. In Germany very great patronage is given to science, magnificent laboratories have been built, and the students, who after they are sufficiently advanced are encouraged to make original investigations, contribute at present most largely to scientific chemistry.

13,055. The continental laboratories are chiefly connected with the Universities, are they not?—Yes, they are connected with the Universities or with teaching institutions, but at the same time students are encouraged to continue researches, in fact very much like what was done on the establishment of the College of Chemistry in England. When the laboratories were completed, about 25 years ago, a great number of gentlemen made use of them, who had completed their education, but who were desirous of learning the methods of organic analysis. They were encouraged by the director to make original investigations, and then a great number of memoirs were written and contributed to the chemical and other societies as the result of their work. Some very important arts were in consequence, developed, particularly the manufacture of colours; for instance, the aniline colours were first produced by former students of the College of Chemistry.

13,056. I presume that this proposed laboratory would be in London, or in its immediate neighbourhood?—Yes, the central laboratory ought to be in London, but it would be an advantage if branch laboratories were hereafter established in some of the larger commercial centres, as, for instance, in Manchester and Glasgow.

13,057. Do you think that any other laboratories would be needed?—I attach the greatest importance to a chemical laboratory, because I believe that chemistry is destined to play a very important part in the advancement of the arts in all civilised countries, but there also ought to be a physical laboratory, very much on the same footing as the chemical laboratory, and in which facilities should be afforded for conducting physical investigations.

13,058. You would give admission to those laboratories on the same principle as to the chemical laboratories?—Yes, to men who could show that they were qualified to make a beneficial use of them.

13,059. You think that any investigations required by the State should also be conducted there?—Yes, they should be conducted in either the chemical or physical laboratory, according to the nature of the investigations. For example, there were a great number of investigations carried on at Woolwich relating to the strength of different alloys whose chemical composition was determined by analysis. Such investigations would be very well conducted in the chemical laboratories.

13,060. Would both those laboratories, in your opinion, require to be on an extensive scale?—I think that the chemical laboratory, besides conducting investigations for the State, ought to afford accommodation for about a hundred workers, and possibly the physical laboratory for about half that number.

13,061. Could you give the Commission any rough notion as to the cost of the buildings and the apparatus?—I should think about 50,000*l*. for the buildings of the two laboratories, and 10,000*l*. for their outfit.

13,062. With respect to mechanism, do you think that any new establishment is requisite?—I think there ought to be facilities afforded to students of engineering to become acquainted with all the known methods of transmitting motion, and the principles on which those contrivances are properly set out. For example, the form of the teeth of wheels and cams, the combination of link work, the combination of epicyclic trains, and a number of those things which are known as contrivances in mechanism for transmitting either constant or variable motion. These subjects have been very well treated of by Professor Willis in his work on the Principles of Mechanism

W. De La Rue, Esq., D.C.L., F.R.S.

12 July 1872.

which formed, I presume, the basis of his teachings at Cambridge. There are some models which were purchased at my recommendation from the last Paris Exhibition by the South Kensington authorities, which are examples of the kind of things which it would be well to collect together. There ought also to be models illustrating the principles of different structures relating to civil engineering. I had not a previous knowledge that such existed in any government department until the other day I happened to visit the laboratories of the South Kensington Museum, and there I saw that for the class of mechanics (Mr. Goodeve's class), there were many such models to illustrate the subjects of which I have been speaking, but of course they were special appliances for teaching. Men who require information respecting the resources of mechanism ought to have an opportunity of readily seeing all the principal contrivances which might be applicable to any mechanical invention. I do not wish to give evidence particularly about engineering, because I suppose there are others much better qualified than myself to do so.

13,063. Do you think that the establishment of those Government laboratories would be likely to give rise to complaints from any existing institutions?—I think not, if those Government establishments were not educational establishments. There would be a natural jealousy on the part of educational establishments if the Government were to undertake to educate students without charge; but what I contemplate is merely that facilities should be given to men who have already been educated, and not to interfere at all with the functions of educational establishments.

13,064. Would you preclude those who resorted to those laboratories from receiving any advice or assistance from the directors or managers of them?—Undoubtedly not, but the advice which they would seek from time to time would be of a different character from what they would receive during a systematic course of instruction.

13,065. You would have nothing in the way of courses of lectures?—I do not contemplate that in any way.

13,066. What is your opinion as to the necessity in the physics of astronomy?—I think that the time for the State providing means for reducing observations has now come, when the State should take up, besides mathematical astronomy (which deals with the places of the stars and planets, and the moon especially), physical observations, more particularly observations of the sun, which appear to me to bear directly upon meteorological phenomena. A system has been devised for solar observation and worked now for some years, which presents no more difficulty than the ordinary current observations of an observatory; I allude now to photographic observations of the sun, which may be made daily, and as the reductions are not very difficult or onerous, the whole thing might be conducted at a very small expense. Indeed the Board of Visitors at their last meeting recommended that those, and also spectroscopic observations, should be taken up at the Observatory at Greenwich, and I believe it is in contemplation to establish such a series of observations as part of the current work of the Royal Observatory. But there are other branches of physical astronomy which are of an experimental character and therefore not to be so readily dealt with—some of which require the devotion of so long a time and are so expensive that private individuals can hardly be expected to carry them on for a sufficiently long period. For example, we cannot know much of the more minute changes of the sun's surface unless we take photographs on a larger scale than are now contemplated at Greenwich; it is quite possible to make such photographs of the sun on a very large scale, say 12 times the diameter of those to which I have alluded, and which have been made at Kew during the last 10 years, namely four inches in diameter. It would be very advantageous to have daily photographs of portions of the sun's surface on a scale of four feet to the sun's diameter; I have done this in my own observatory and have surmounted the difficulties connected with it; it necessitates a certain staff of assistants, and it requires continuous superintendence, hence it is necessary that an amateur astronomer who undertakes such work should have leisure during the day, and that he should be able to pay for duly qualified assistants, and such men have to be highly paid.

13,067. Do you think that provision for carrying out observations of this character should be in connexion with the Greenwich Observatory?—In connexion with the Greenwith Observatory, yes, but at the Greenwich Observatory I should say not. I do not think, in the first place, that there is space enough at Greenwich, and the duties of the staff are already so very onerous that it would require a separate establishment for such special work; besides other new buildings it would entail a chemical laboratory, and there is hardly space for those at Greenwich. I believe also that it would cause too divided attention on the part of the Astronomer Royal, if he were called upon to personally superintend investigations in the physics of astronomy, although I think it would be very desirable that any new establishments, if they are to exist, should be affiliated to Greenwich.

13,068. Should they be in the neighbourhood of Greenwich?—Not at all necessarily so. In fact Greenwich would not be at all desirable for some class of observations, it is much too near London.

13,069. Would you place the proposed new observatory for those purposes in any respect under the control of the Astronomer Royal?—It would be desirable that the State should have to deal only with one astronomer. Possibly by the increase of the claims upon his attention it might be desirable for the Astronomer Royal to have directors under him, so that he should not have to devote so much time to details even of the Greenwich Observatory, but I do not think that the State ought to have to deal with a great number of astronomers, indeed there might be some difficulty in its doing so.

13,070. Have you any recommendation to make with regard to the situation of such an observatory in England?—No, it would have to be sought for.

13,071. Besides the establishment of an observatory of this character in England, do you think it desirable that others should be established elsewhere?—Undoubtedly. In the first place, with regard to photographic observations of the sun, it is essential to have a daily record of solar phenomena. At the Kew Observatory during the last 10 years we did get observations on somewhat more than half the number of days of the year, but frequently it was cloudy for several consecutive days, and then the history of sun spot phenomena was in a great measure lost, not only for those days when it was cloudy, but sometimes the observations of months were seriously affected by the want of connecting links in the phenomena. Therefore, in order to obtain a daily record, I would advise that one or possibly two observatories should be established in India, and one at the Cape of Good Hope, and it would be desirable to have others in Australia; but then the governments of Australia being independent in a measure of the British Government, the British Government would not have direct control over them. I know that an opinion has been expressed by some astronomers that a very large telescope, for example, like that at Melbourne, could not be so advantageously employed in England as in some of the hill districts of India. It is true that more days might be available in India than in England, but still the difficulty of working at a distance from industrial centres in a great measure diminishes the advantages of an observatory in such a locality, and although there may not be so many fine days, I mean fine in an astronomical sense, in England as in other countries, yet an immense deal of good work can be done in England, and I should very much like to see such an instrument as has been sent out to Melbourne at work in England as well as in India, and placed under the Government Astronomer.

13,072. Are there any other objects besides those

W. De La Rue, Esq., D.C.L., F.R.S.

12 July 1872.

which you have already referred to, which you think would be amongst the objects to which those observatories could be applied?—I think amongst the desiderata we ought to have the moon properly mapped, and we ought to know whether or not there exists really a physical libration of the moon, and to that end I would advise that photographic pictures should be made with an equatorial four feet in diameter which would give them over three inches in diameter; on such photographs, objects on the lunar surface could be measured with the requisite accuracy for the determination of the question of physical libration. With regard to the mapping of the lunar surface, photographic should be combined with eye observations. The lunar photographs forming the basis of the work to be completed subsequently by eye observations and micrometrical measurements. The motion of the stars is another subject of great interest, both Mr. Proctor and Dr. Huggins, by very recent investigations, having shown that there is a close connexion between certain stars situated near together which appear to move in a common direction. Many of those in the same constellation appear to be approaching the earth, while others appear to be receding from the earth, and also to be drifting in the same direction at right angles to the line of vision. It is desirable, as a matter of science, to know, as far as possible, all that is connected with the motion of the sun in relation to the fixed stars, and to know whether those stars have any proper motions of their own when the sun's motion has been eliminated.

13,073. Could those various objects be conveniently comprehended in the work of such observatories as you have recommended?—Yes. In the work of about two such observatories in England, or two branches of the same observatory in England, apart from such photographic observations of the sun as are undertaken at Greenwich.

13,074. (*Dr. Sharpey.*) I understand that the great laboratory established by the State which you contemplate should be devoted partly for carrying on chemical inquiries required by the Government, and partly to afford facilities to independent chemical investigators who are engaged in original research?—Yes.

13,075. You would, I suppose, understand that there would be a director of this establishment?—A director, and qualified chemists to act as assistants.

13,076. Do you think that there would be constant employment for such an establishment in work which the Government would require to have done?—I think so. In fact there is at Woolwich, for example, constant employment for a high class chemist.

13,077. Would you transfer the work now done at Woolwich to such a laboratory?—Part of the work, but I would except such special work as could be better done at each of the Government establishments. Special investigations would fall within the duties of the central government laboratory. The testing of the purity of the products to be used in the department, and routine work would be better conducted in those establishments.

13,078. With respect to the other purpose of the laboratory, do you think that there would be a sufficient number of independent inquirers to occupy an establishment like that?—I think that there would be a great number of men who would be very glad to avail themselves of such opportunities as a laboratory of that kind would afford, and their doing so would not add materially to the cost of the establishment.

13,079. Do you think that at present there are men that have in view such inquiries, but who are prevented from undertaking them for want of an establishment of that sort?—Yes, I judge in some measure from the experience of the College of Chemistry. When it was first established there was a rush of workers, I suppose 40 or 50 men joined the college; they were desirous of undertaking original investigation, but they required first of all to receive the necessary instruction in the German methods of organic analysis: these gentlemen continued for some time working in the laboratary; but now we have a dearth of such investigators.

13,080. At that time there were fewer laboratories, were there not, belonging to independent institutions?—That is true.

13,081. The College of Chemistry was under a very eminent and very able director, was it not?—Yes, under Dr. Hofmann.

13,082. Do you not think that a good deal of the success of the researches made in that institution with regard particularly to the discovery of colours, and the like, depended very much upon its being under the direction of a man like Dr. Hofmann?—Undoubtedly it did do so in a great measure, but not entirely; the independent position of the College had a great deal to do with the devotion to it of the workers. In England now we have a greater number of educational establishments, but the students when they have completed their education do not remain in them for the purpose of making investigations on their own account. Even the College of Chemistry is becoming more an educational establishment than a working establishment. The College of Chemistry was essentially in its earlier days an assemblage of zealous men who were desirous of making investigations, and who carried them on with great ardour, aided by the advice and sometimes with the co-operation of Dr. Hofmann, the director.

13,083. Then it was maintained by private contributions, was it not?—Entirely by the subscription of members and by private contributions for a certain time.

13,084. But it failed upon that footing, did it not? I mean financially it could not be maintained?—It was found that the members' subscriptions, which soon began to fall off, together with the fees from the students, were insufficient for its maintenance; but it was sustained by the contributions of a number of gentlemen, Lord Ashburton and Sir James Clark, Sir Wm. Tite, myself, and other members of the Council.

13,085. But they were unable to carry it on?—That is not strictly correct, because it was efficiently supported by the donations of members of its council.

13,086. Then was it not adopted as a Government establishment?—An opportunity offered of allying the College of Chemistry with the School of Mines, and seeing how precarious the means of such a college were likely to be, and that when the enthusiasm of those who had established it had died out, the funds might possibly fall short, the council thought it advisable to attach it to a Government establishment already existing; but there were no debts except such as were always met from time to time. It was really mainly sustained by the council of the College. Originally it was established on a false basis, for the subscribers were to get much more than the worth of their subscriptions by analyses, and so on—that was the real cause of the withdrawal of subscribing members.

13,087. But eventually the Government, of course, had to expend a certain sum of money in order to defray the expense of adopting that establishment as a Government institution?—They had only to continue to pay the rent and taxes and the professor's salary. The history of the College after its transference to the Government I do not know much about, but it was a positive gift to the Government of a certain amount of property.

13,088. Do you mean that the Government did not pay for the property?—It was all given to the Government, the Government paid nothing whatever for it. The apparatus and the building, which had been erected at considerable cost, were, with the consent of the members at a general meeting, presented to the Government.

13,089. Do you know under what advice the Government undertook to maintain that establishment as a public establishment?—That I cannot tell, but it was, in my opinion, very sound advice; I know that Sir James Clark and Lord Ashburton opened the negotiations with the Government.

W. De La Rue, Esq., D.C.L., F.R.S.

12 July 1872.

13,090. With what department of the Government?—That I cannot tell.

13,091. Supposing that there had been such a consultative council as you propose, would it not have been advantageous to take their advice upon the expediency of such a proceeding?—I think that it would be one of the functions of such a council undoubtedly to advise the Government upon questions of that nature, and with regard to all other scientific matters, grants of money, or the establishment of fresh teaching establishments.

13,092. Then one advantage would be that the public would know on whose advice any such step had been taken by the Government?—Yes.

13,093. Whereas, with reference to the College of Chemistry, it does not seem clear who advised the Government upon the subject?—I think there would be no difficulty in finding it out, but I have no recollection at the moment of the stages of the negotiation. I think that everything connected with it is published. There was no secret about the matter.

13,094. I think you mentioned that there was a great contrast between the extent and the value of original research in chemistry in Germany and in England?—Yes.

13,095. To what do you ascribe that difference?—I ascribe it to the State patronage of science and the steps which Germany takes for the advancement of science, first of all, in taking care that the best men are selected to be placed at the head of such establishments as schools and the vast number of gymnasia which are all of the very highest class, and yet are accessible to the poorest boy. I also ascribe it to the care which is given to the cultivation of every branch of science; and, moreover, to the positions and places at the disposal of the Government which are given from time to time to men who render themselves eminent in science.

13,096. Are there any laboratories known to you in Germany which are independent of educational establishments?—No, they are all in Germany, as far as I know, connected with educational establishments.

13,097. So that those really original researches come from advanced students?—Yes, they almost always come from advanced students. It is very rarely that a man undertakes original investigations unless he has been trained at some educational establishment.

13,098. It is the advanced students in those universities and gymnasia, is it not, that work in the laboratories there?—Yes, they work in the laboratories while students, and in some cases continue their work after they have gone through the course of instruction.

13,099. Is not there more opportunity for a scientific career for a young man in Germany than in this country?—Yes, far more.

13,100. By means of professorships, extraordinary professorships, and the like, in the numerous universities and higher schools in Germany?—Undoubtedly such appointments are a direct encouragement to the culture of science.

13,101. Do not you think that that must bear a considerable part in creating the difference between this country and Germany with regard to scientific results?—Undoubtedly it plays a very important part, but I do not know that the same legislation which suits Germany would exactly suit England. But there ought to be careers open to men in England who have received a scientific education, for example, teacherships and professorships, and as scientific heads of government departments.

13,102. To revert to a question which arose before, do you think that there really would be a sufficient number of qualified investigators to occupy an establishment of chemistry such as you suggest; that it would not, in some measure, stand idle, so to speak?—I think not.

13,103. Would it be economically thrifty to create an establishment like that?—I think that it would have a very important bearing upon the advancement of chemical science, and that the country would be much benefited by it.

13,104. Do you not think that something might be done by aiding existing laboratories and extending them; could they not be made to afford facilities to independent inquirers, if they needed them for the carrying on of research?—Something might be done in that way, but then there is an aversion on the part of many men to enter an educational establishment after they have passed through their educational career.

13,105. They do not necessarily go there as students, but as independent workers, to whom an opportunity is afforded for carrying on research. I believe that is not uncommon?—If there were a choice between the mode you suggest and no other, I think that some good might be done by aiding educational establishments; but I believe that the more advantageous course would be for the State to afford facilities in the laboratory which it might require for other purposes.

13,106. (*Professor Stokes.*) The primary object of the institution of the laboratory would be to do chemical work for the State, would it not?—Yes, and at the head of it there should be the most eminent chemist whom we could obtain for its direction, and he ought to be assisted by a properly qualified staff of assistants, who would occupy positions analogous to those which Dr. Sharpey was alluding to in reference to Germany. And if such a laboratory were established, I think that a great number of men of scientific attainments would be found desirous of availing themselves very freely of the facilities which such an establishment would offer.

13,107. (*Dr. Sharpey.*) How would you supply similar facilities to men in the provinces who were capable of undertaking scientific work?—In the large manufacturing centres there might be one or two branches of the central laboratory, but I imagine that men would be induced to come from the provinces to work in London, provided they were placed at no greater expense than the mere living.

13,108. You are aware, are you not, that they are about to extend the chemical laboratory at Owens College in Manchester?—Yes.

13,109. Do not you think that advantage might be taken of that, to extend it sufficiently to meet the case of independent inquirers who wished for facilities for work, rather than create a second one there?—I should answer that almost in the same way that I answered the question about educational establishments in London; I think that it would be far better to have an adjunct to Owens College than to have nothing, but I believe that a greater number of men would be found willing and desirous of entering an establishment founded by the State which had not at all an educational character, than by becoming as it were students at a college; I am talking now of men who have been educated thoroughly, and who are quite capable of working on their own account.

13,110. Supposing it were in Manchester, do you rather think it would be better to have a separate establishment?—I think so; but I look upon those branch establishments as something for the future.

13,111. Do not you think that it would be advisable to take advantage of the Professor of Chemistry and his assistants at the existing establishment rather than to make a second one under officers paid by the State?—The difficulty which I see in this matter is that the State would not have the direct control over such establishments.

13,112. They might institute an inspection and receive reports, might they not, from year to year?—That is true, but the State ought to have the power of removing from the head of any establishment a director who did not quite fill the position which it was intended that he should fill; I think we should then have a higher class of men aspiring to such positions than we should under other circumstances. It will be admitted that the same quality of mind may not suit both educational teaching and the directorship of a State laboratory, and I believe, therefore, educa-

W. De La Rue, Esq., D.C.L., F.R.S.

12 July 1872.

tional and State departments of science should not be combined under one direction.

13,113. Then you would attach great importance to the qualification of the director to such a laboratory ?—Undoubtedly, it is most essential to have the highest talent.

13,114. Is not that rather inconsistent with your view that independent inquirers who were qualified to carry on researches would not like to go into an establishment in which they were placed under the direction of anyone in the shape of an instructor ?—I do not think my words bear this interpretation.

13,115. Is not it the tendency of your evidence ?—Scarcely so. What I meant to say was this, that I think there are a great number of men who would be fully qualified to undertake original research, who might not like to appear to be students at an educational establishment.

13,116. The physiological laboratory at Leipsig under Professor Ludwig is an educational establishment ?—I suppose so.

13,117. But probably you are aware that many gentlemen of position in this country go over there to get the opportunities afforded for carrying on inquiry in that laboratory ?—I have no special knowledge of that fact, but I can quite conceive it to be the case.

13,118. I could mention half a dozen who have been in no way prevented from taking advantage of that or similar establishments from their being connected with education ?—Gentlemen might sometimes be induced to go abroad for the purpose of carrying on such investigations, at a College, when perhaps they might not like to do it in their own country. I am not acquainted with the details of the physiological laboratory of Leipsig.

13,119. (*Professor Stokes.*) With regard to the scientific board or council of which you spoke, you threw out a suggestion that frequently it might not be necessary to call the whole of the board together, for instance, a question might arise possibly involving a knowledge of chemistry, mathematics, and mechanics, but on which a physiologist would be of no use ; another might arise involving a question relating to museums with respect to which a mathematician, or a chemist, or a mechanician, would be of no use ; does it appear to you that it would be desirable to make the numbers of the board larger than what you at first mentioned, in order more fully to represent the different branches of science, but only to call certain detachments of them together at the same time, and to divide the remuneration of the whole board in a different manner, say, according to the attendances, so as to render that possible without additional expense ?—I am one of those who consider that the whole possible expense is so insignificant in comparison with the advantages that would be derived from such a board, that I think that men who are liable to be called upon at any moment, and who must hold themselves ready to serve whenever called upon to do so, should receive an adequate fixed remuneration, and that the distribution of the remuneration in accordance with the attendances would not meet the requirements. In my suggestions I have confined myself very much in recommending as members of the board those conversant with the sciences of which I know some little ; but if 12 men were not found to be sufficient to include all branches of knowledge, then I think it would be desirable to increase the number. In naming 12, I thought that special advisers might occasionally be called in who would be remunerated according to their attendance. The chief board, which ought to be of the very highest scientific standing, should in my opinion be sufficiently remunerated to compensate for this liability to be called upon at any moment. As the gentlemen composing it would be always liable to be disturbed in their ordinary occupations or in their recreation, I cannot conceive that any possible question of remuneration ought to enter into the consideration of a matter of such great importance. Supposing, for example, there were 24 instead of 12, and that 24,000*l.* were provided for the council, that appears to me to be a very insignificant sum in proportion to the advantages which the State is likely to derive from the services of such men. I might add that high-class clerks in a large commercial establishment would receive more remuneration than what I have mentioned.

13,120. Then it would be in accordance, I take it, with your original suggestion, that the number of the board being somewhat restricted, the members should freely and perhaps frequently go out of their own body to seek extraneous advice ?—Yes.

13,121. (*Professor Huxley.*) I understood you to say that you thought that the establishment by the State of an astronomical laboratory was wanted ?—Yes.

13,122. In your judgment it ought to be quite separate from the ordinary astronomical observatory ?—Yes, the physical observatory and conjoined laboratory ought to be in a separate locality.

13,123. But in your opinion it should be under the general governance of the Astronomer Royal ?—It appears to me that there would be a great advantage in the Government having to deal with only one scientific head of any particular department. But undoubtedly there ought to be at the head of the physico-astronomical observatory an astronomer of very high scientific position who would conduct in a partially independent manner the researches to be carried on in such an observatory.

13,124. Would you propose to make the Astronomer Royal a sort of general manager of things relating to astronomy, and to have a separate director for the observatory, and for the physical laboratory and observatory ?—Yes. It appears to me that if the duties of the Astronomer Royal are to be multiplied by the extension of astronomical observation and research that would be at least a necessary consequence.

13,125. (*Mr. Samuelson.*) Assuming that a Science Minister were appointed, and that he had a permanent scientific secretary, and assistant secretaries acquainted also with science, are you quite clear that then there would be a great advantage in a permanent board, as compared with the plan of obtaining advice, from time to time, of persons whom those high officers might consider to be well qualified to give advice upon special subjects which might arise ?—Science is really now so extensive that one could hardly imagine any secretary, so to be intimately acquainted with every branch of science as to be able, even with the aid of his assistant secretaries, to advise or to point out where to obtain specific information on every question which might be brought under consideration. I think, therefore, that there would be a very great advantage for the Science Minister to have a sufficiently numerous advising council.

13,126. Even with a view to seeking advice ?—The seeking of external advice would be in some special case or cases. Any broad scientific question would in most cases be easily resolved by the members of the council ; but there are certain cases which one can foresee might arise requiring specific information, and more special knowledge than those gentlemen are likely to possess on every possible subject. I think there ought to be a body of men, who could be immediately called together, whose time was so far at the disposal of the State that they might be assembled on every occasion and at any time to advise the Science Minister. Then we should get prompt action, instead of questions being allowed to drag over years and years without any practical solution being come to.

13,127. Assuming that science were a department of the ministry of education, for instance, and that the permanent secretary of that department were the permanent secretary for science as well as for education, would you in that case consider the appointment of a council more or less necessary than in the case which you have assumed of the appointment of a science minister with scientific secretaries ?—If I understand the question aright, it is one which has reference to the greater or less advantage of a council according to the scientific capacity and the extent of work of the chief secretary.

W. De La Rue, Esq., D.C.L., F.R.S.

12 July 1872.

13,128. Of the chief secretary and of his permanent secretaries?—I imagine that it would be advantageous to have a gentleman conversant with general science as the secretary, and I think that his attention should not be divided too much by a multiplicity of duties. He might be eminent in one branch and have a good general knowledge of science, and yet even with these qualifications he might not be able to advise upon all subjects, consequently I hold to the opinion that there ought to be a permanent council of scientific men.

13,129. I am assuming that the permanent secretary as well as the minister were rather political officers than scientific men; would you in that case consider the establishment of a council to be more advisable or less essential than in the case which you have assumed of a science minister and a qualified scientific secretary?—I hardly know how to give an opinion as to degree. I think it is so important that there should be a council consisting of a number of eminent men, that in any case I think it ought to exist, and I believe that it would be of advantage that the secretaries should also be men conversant with science.

13,130. You think that the necessity would be equally great, practically, whatever might be the arrangements of the Ministry of Science?—Undoubtedly. I cannot conceive that the special knowledge of a secretary or two assistant secretaries could in any way influence that question. I think that the Government ought to have at its command, whenever required, the services of the most eminent men in science which England possesses.

13,131. What effect do you consider that the existence of such a council would have upon the composition of the more scientific departments of the public service; do you think, for instance, that the organisation of the Admiralty, the War Office, and the Public Health Office, might be less scientific than would be necessary under other circumstances if there were a special Government department to advise upon scientific questions?—I hardly can say that I would advise any of those departments being less scientific than they are now. What I mean to say is this, that I think all those branches of the Government should be specially scientific each in its own department, but I do not think that they are too much so now.

13,132. (*Professor Huxley.*) Is it not probable that the more scientific counsel the executive department had the more likely they would be to appreciate that good advice which the scientific council might give them than if the council were less highly qualified?—I should say so.

13,133. My question was this: would not the administrative officers of any government be more likely to take the advice, or to be able to appreciate the advice, of such a body as a scientific council the more heartily the better they were themselves scientifically trained?—Undoubtedly. I think that whatever might be the constitution of the council, the heads of those departments should not be in any way less qualified than they now are. They should not be merely administrative men; they should be men capable of administering, but at the same time they should have special scientific knowledge. I mean to say that I would not remove from them the responsibility of a proper amount of scientific knowledge in the conducting of their own departments.

13,134. (*Mr. Samuelson.*) In the event of the appointment of a scientific council, have you no fear that there might be some collision, or, at any rate, considerable friction, between that council and the scientific departments of the public service?—Probably at first there might be, but ultimately I believe the confidence of those directors of the departments would be gained by the very sound advice which they would receive from a body constituted such as I conceive it ought to be.

13,135. Has it occured to you whether any modification of the Government Grant Committee of the Royal Society might, either temporarily or permanently, fulfil the office that you would assign to such a council?—The fund given to the Royal Society for distribution is administered exceedingly well and very carefully by the Committee which is appointed to deal with it; but it is so very small a matter, and so insignificant in comparison with the advancement of science which the steps under consideration would afford, that it hardly enters into consideration. Supposing 5,000*l.* or 10,000*l.* were given to the Royal Society to aid investigations, I do not think that that in any way ought to weigh in the consideration of the establishment of a science minister whose functions would be altogether larger and much more important. We want science really cared for in England by the State, and we want all State questions relating to science properly considered by a body capable of dealing with them.

13,136. And that body responsible for it?—Yes. There is a great difficulty in fact under existing circumstances in the State dealing at all with science or with scientific men. There is no department of the Government, so far as I know, which is able to fully appreciate the advantages that science confers on the State.

13,137. (*Chairman.*) Is there any point upon which you would think it advisable to make any additions to your evidence?—I think not.

The witness withdrew.

E. Townsend, Esq., M.A.

EDWARD TOWNSEND, Esq., M.A., examined.

13,138. (*Chairman.*) You are Professor of Engineering in Queen's College, Galway?—Yes.

13,139. Will you be so good as to state the provision made for instruction in engineering in that College?—The engineering students in the College go through a three years' course. The first year is principally occupied with chemistry, modern languages, pure mathematics, and in my department I give a course of lectures on descriptive geometry, the formation of curves, such as occur in machinery, perspective, and isometric drawing, and the construction of shadows; in fact geometric drawing in general. In the drawing school the students of the first year are occupied principally in making surveys from field books, and in doing perspective and isometric drawings. In the second year the students take out a course of mixed mathematics, and also a course in experimental physics. They also attend a second course in pure mathematics, and they attend two courses in the engineering school. In the engineering school in the second year I commence with the construction of the instruments, their adjustment, and manipulations. Then I go on to the theory of levelling and surveying, with and without the aid of the theodolite, laying out of railway curves, measuring earthworks, and subjects of that kind, and in addition to that I take the students out in the field. In the second year we make a practical section in the field: we also make a large survey with the chain, and a traverse survey; we measure heights with the theodolite, and lay out a railway curve. In the office work, in the second year, the students are principally occupied in plotting their section and in taking out the earthwork for a line of roadway, computing the acreage of their surveys, and in drawing bridges, roofs, and pieces of machinery. In the third year the engineering students take out two courses in natural philosophy, an advanced course in mixed mathematics applied, and a course in mechanism, or natural philosophy applied to machinery. They also take out a course in mineralogy and geology, along with two courses in the engineering school. In the third year the lectures consist principally of pressures in earthworks, the stresses in iron bridges and roofs, hydraulics, the supply of water to towns, drainage, pumping engines, locomotive engines, the Gothic styles and the classical orders in architecture. In the drawing school they are occupied with a more

E. Townsend, Esq., M.A.

12 July 1872.

advanced kind of drawing, such as bridges, canals, locks, and iron and stone bridges. That is the course of lectures which they go through in engineering. They pass several examinations during the course. There is a sessional examination at the end of each year. The examinations consist of University and College examinations. In the College there is a special examination at the end of each year irrespective of the scholarship examinations, which are held for scholarships and prizes, and in the University they pass two examinations, one at the end of the second year and the other at the end of the third year, which is called the diploma examination.

13,140. Then there are three College examinations?—There are three College examinations and two University examinations, irrespective of the scholarship examinations.

13,141. Does the University grant any actual degree in engineering?—It grants the degree of Bachelor of Engineering.

13,142. What scholarships and prizes are open to students in engineering in the College and in the University?—There are five scholarships in engineering worth 20*l.* a year each, two in the first year, two in the second, and one in the third, and the scholar pays but half the College fees.

13,143. Is each scholarship only tenable for a year?—Each scholarship is only tenable for one year.

13,144. Are there any University scholarships or prizes?—There are two University prizes that were founded by Sir Robert Peel, called the Peel Exhibitions, which are given at the first University examination in engineering; one is 40*l.* in value and the other is 30*l.*

13,145. What fees are paid by students in engineering?—About 10 guineas on the average. In the third year it is something smaller; I think it is six or eight guineas.

13,146. In the opinion of the College authorities, to what extent ought practical instruction to be carried in the school?—With regard to the amount of practical instruction that can be carried on in the school, the College does not profess to give the knowledge that is requisite for a practical engineer. Our engineering students, after taking out their diploma in the University, are recommended to go into the office of an engineer for one or two years to learn the practical part of their work. As far as the College is concerned, it is the general opinion that it would be utterly impossible to give the amount of instruction there which would enable an engineer to undertake works on coming out from the College. They may be taught in the College surveying, levelling, the making of traverse surveys, the laying out of railway curves, and simple practical operations of that kind; but as to getting up extensive plans for supplying towns with water, or larger engineering works of that kind, I do not think it could be done with advantage in the College.

13,147. At what age do the students in engineering usually obtain their degree?—I think about 20 or 21.

13,148. Do they not find themselves to be rather old to go to an engineer's for the practical part of their education?—No; it may vary from 19 to 21, but I fancy that they very seldom take out their degree before 19.

13,149. What number of students in engineering have you usually in the Galway College?—The average is 16 in the three years. I cannot speak very accurately about the other Colleges, but I think in the Cork College the number of students is greater. It is a much larger town, and there are more wealthy people there. I think the average of our three Colleges is something like 60. The number has declined a little the last couple of years.

13,150. Can you state what are the literary attainments that are required from students in engineering?—Independent of the Matriculation examination, they attend a course of French or German, which is compulsory, during the first year, and they are examined in this at their first University examination.

13,151. Are you able to say how far the system adopted in Galway is similar to the system adopted in other engineering schools?—It is precisely the same as the system adopted in Trinity College, Dublin, and Glasgow and Edinburgh, and it is pretty much the same as the school in Paris, the École Centrale, which is one of the principal engineering schools there; and with regard to London, I think it is pretty much the same as in King's College, London, and University College.

13,152. (*Professor Stokes.*) Do not the Dublin students actually practise while they are going through their University course?—It is not usual; they first take out their diploma. A man may attend during the third year, if he has an opportunity, the office of an engineer simultaneously with the course in the University, but it is considered more advisable not to do so until he has completed his College course altogether. I am not aware of any such regulation in Trinity College, Dublin. I know it was not so in my time, for I took out my diploma there; but after the diploma the students are directed to enter the office of an engineer having the construction of works.

13,153. (*Chairman.*) Can you give the Commission any information with regard to the nature of the instruction given in the school of chemistry?—Yes. There is first a course of lectures given in the first year, extending over three terms. The first and second term and part of the third term are principally occupied by lectures on inorganic chemistry, and a portion of the third term is devoted to organic chemistry; and in addition to this there is a practical course of instruction given in the laboratory which the students attend, and for which there is a very moderate fee.

13,154. Is the College provided with an adequate chemical laboratory?—Yes, it is.

13,155. Can you give us any information with regard to the nature of the instruction given in the school of geology and mineralogy?—The course of lectures in geology and mineralogy extends over three terms also. The first term, I think, is principally occupied with physical geography and physical geology; the second term, I believe, is occupied with lectures on mineralogy and the nature of rocks, and the third term with palæontology; and in addition to that the students make practical excursions, accompanied by the professor. The museum is well supplied with fossils, which are ranged stratigraphically; there is a very good supply of rocks, both native and foreign, and of course Irish; and there is a very good supply of models of crystals, along with diagrams, and geological maps and sections that are used for lecturing purposes.

13,156. What is the instruction given in the school of natural history?—There is a course of lectures on zoology, extending over a portion of the three terms, and also a course of lectures on botany. There is a museum of natural history which is tolerably well supplied with animals, and very fine diagrams and plants. The professor has the power, which he exercises, of getting flowers from Dublin for practical instruction in botany, and the students make botanical excursions and herborisations, accompanied by the professor.

13,157. How are the numbers at the College who take up those branches of knowledge compared with those who are applying themselves chiefly to classics or to mathematics?—I should think that there is a far greater number taking out scientific courses in comparison with those attending purely classical courses.

13,158. Are you of opinion that engineering schools generally are under disabilities in consequence of the establishment of Cooper's Hill College?—We feel that it is a great hardship to students entering the Irish Colleges, or the English or Scotch Colleges, to have to come to London and pass an entrance examination at the Cooper's Hill College, which is rather of an elementary nature, in order to compete for the Indian appointments, which are given three years subsequently. And if they do not pass that preliminary entrance examination they cannot compete for the final examination which takes place three

E. Townsend, Esq., M.A.

12 July 1872.

years after. It is a hardship for the Irish students to come over here to pass an entrance examination which is rather of an elementary kind, when they can do so at the Colleges, and really do so.

13,159. Except with respect to this elementary examination, do you consider that in other respects your engineering students are under a disadvantage?—I do. With regard to the Cooper's Hill College, I find, by the latest information given, that before a candidate can compete for the final examination he has to pay a fee of forty pounds. For the Civil Service Indian appointments the candidates have only to pay five guineas, and I am not aware that they have to pay any fee in the telegraph or forest service, but I have a paper of the instructions, by which I find that before they can compete for the Indian engineering appointments in 1874 they will have to pay a fee of 40*l.*

13,160. (*Dr. Sharpey.*) Have they to go through any prescribed course of instruction before they go into that examination?—No, there is no prescribed course: they merely give a list of the subjects of examination for entrance.

13,161. For the advanced examination must they show that they have been studying engineering in any institution?—I do not know that they actually require them to study in any college, but they require them to produce a testimonial or certificate to the effect that they have been engaged in works for at least eight months.

13,162. Have they to compete with the pupils of Cooper's Hill College?—There is some doubt about that. It states that the final examination is to be qualifying; but whether they are to compete with the Cooper's Hill College pupils I cannot say.

13,163. (*Professor Smith.*) It is not advertised as a competitive examination, is it?—I think it is stated that the second examination is qualifying, if they are found to come up to the standard.

13,164. (*Dr. Sharpey.*) Supposing there are a number that are found qualified, and there are not appointments for all, who makes the selection?—The Civil Service Commissioners conduct the examination; I cannot say who makes the selection. Then with regard to the engineering students, they labour under some disabilities compared with the students studying for Government employment in other services. For instance, take the Civil Service; after they have passed the first competitive examination, which is the great trial examination, each successful student is allowed by the Government 300*l.* in order to study the more practical part of his profession during the two years of probation before he passes the second examination. In the Forest Department I think they are allowed 100*l.* a year for two years after having passed the first examination, and in the Telegraph a similar sum; and in the Medical Department, when the students go to Netley, after having passed the first competitive examination, they are allowed 7*s.* a day, but in the engineering they get nothing. An engineer, in my opinion, requires it a great deal more than any of the other departments, because his education is far more expensive. After he leaves College he has to pay a large fee of at least 100 guineas a year to any engineer who has the construction of works, in order to get an opportunity of practising for two years.

13,165. (*Chairman.*) Has any reason been assigned for this distinction?—I have not heard of any.

13,166. Do a large number of your engineering students study at Galway with a view to obtaining appointments in India?—Nearly all the students look forward to Indian appointments.

13,167. (*Professor Smith.*) Do your students offer themselves, as a rule, for the competitive examination for Indian appointments?—Yes, they all study with that view.

13,168. Is there an entrance fee for that competitive examination?—I am not aware that there is any fee for the entrance examination.

13,169. (*Chairman.*) Are there any other points upon which you would like to make additions to the statements which you have made to us?—I should like to say, that as far as the funds at our disposal in Galway are available, I think they are laid out in a most judicious manner for managing the school; but if there were any other fund from which we could draw a small sum, I should like to have an assistant to aid me in the drawing school. I have drawn up a description more in detail of the engineering courses, which I can hand in (*delivering in the same*). [See APPENDIX V.]

The witness withdrew.

A. H. Curtis, Esq., LL.D.

ARTHUR HILL CURTIS, Esq., LL.D., examined.

13,170. (*Chairman.*) You are Professor of Natural Philosophy in Queen's College, Galway?—I am.

13,171. And you also hold the appointment of Professor in the University?—I do, by the tenth section of the University charter. We are professors both in the College and in the University.

13,172. But your duties are solely confined to the College, are they not?—No, we examine in Dublin as professors of the University.

13,173. But you do not teach in Dublin?—No, the University is not a teaching body at all.

13,174. Your duties at Dublin are solely those of examiner?—Exactly. The students of the three colleges meet in Dublin for examination in October, both for the previous examinations and the degree examinations. The University examinations of which Professor Townsend spoke are conducted in Dublin.

13,175. Are all the professors in the colleges likewise professors in the University?—Yes, but not all examiners; this will require a little explanation. There was a new charter in the year 1864 issued to the Queen's Colleges, and any professor who did not wish to accept the duty of examining every year was allowed to continue to hold his professorship on the terms of the previous charter, and some few did refuse: Professor DeVericour, Mr. Lewis, the Professor of Latin, and Mr. Read, the Professor of Logic and Metaphysics, a member of the English bar, all of the Cork Queen's College, refused to accept the new charter, so that these gentlemen are not examiners of the University, although included in the list of University professors.

13,176. With respect to all appointments which have been made subsequent to the new charter, the professors are equally professors in the University and in the Colleges?—Certainly, and examiners also. They have no option. There is a salary as examiner for the University annexed to the professorships. Part of our salary is derived from that source.

13,177. Will you be so good as to describe to us the nature and scope of the instruction given in Queen's College, Galway, in mixed mathematics, experimental physics, and applied natural philosophy?—I have five different courses; in fact the number of students attending me is very great, because the arts students, medical students, and engineering students are all obliged to attend one or more of my courses. Medical students are obliged to attend a course of experimental physics, including easy mechanics, mechanics not requiring very much mathematics is in their case included in experimental physics; in other classes experimental physics is supposed to exclude mechanics. The medical class attend generally the first and second terms, the medical education extends over four years, and medical students may take my course in any year they choose. The arts students in the second year are obliged to attend a course in mixed mathematics. I have two such classes, one for honour students and the other for the pass. There are, I may remark, 10 junior scholarships in the second year of arts, and these are equally divided between science and classics. The five science scholars are obliged to take honour courses of pure and mixed mathematics, and the five classical scholars, *A. H. Curtis, Esq., LL.D.*

12 July 1872.

honour courses in Latin and Greek; all are obliged also to pass examinations in the subjects of the classes which they have attended, and, if they do not pass in each of these subjects, they lose their scholarships; they get, however, a chance of passing the supplemental examination afterwards in October. If they do not attend the honour classes they attend the pass. With regard to the engineering class, Mr. Townsend has, I think, explained already that the engineering students of the second year attend two classes; they attend an honour class of mixed mathematics, and also an honour class of experimental physics. With regard to the third year students, I should have mentioned that the arts men of the third year attend, if they choose to select it, the honour class of mixed mathematics, or the honour class of experimental physics, or possibly both. I have had cases where students have attended both. In order to explain this, I may mention that the arts students of the third year are allowed in the University curriculum, which is the one followed out by the three colleges, certain latitude as to the subjects in which they will present themselves for their degree. The College rule is more stringent than the University rule; they are obliged to attend four courses of lectures, of which two may be honour courses selected by the student. In presenting themselves for their degree, candidates for honours will select any one branch, or more, in which honours are given, and they may exclude everything else; but of course they must have passed the College examination previously, and when I spoke of a course of lectures all through, I included in the idea the passing of the examination subsequently, otherwise the course of lectures is lost.

13,178. In all branches is there one College examination annually?—Yes. Every course of lectures has its corresponding examination. There is one exception to the examination being obligatory, the medical students, unless they be scholars or exhibitioners, are not obliged to pass the College examination in my subject, and in some others. This is the only exception.

13,179. Can a student obtain his degree at the University by passing in honours in experimental physics alone?—No, he must take chemistry with it. Chemistry and experimental physics form a group. Perhaps I may add that pure and mixed mathematics form a group, and modern languages form a group. A man must take two languages. Any three of the following—metaphysics, English language and literature, logic, history, and political economy form a group in the same way; but the Calendar will fully explain this. It is a common thing for the students to take honours in two groups.

13,180. Are there a considerable number of students who go through the course of experimental physics?—All the engineering students take the honour class, and any students in arts who are going up for the degree of B.A. in experimental physics and chemistry. Last year my honour class in experimental physics consisted of seven.

13,181. Were they all engineering students?—No; there were three engineering and four arts students.

13,182. Does the University give any degrees that are called science degrees?—There is a degree of doctor of science, and one of bachelor of science; the former has never been given except in two cases; in each case it was an honorary degree which was conferred. Neither of these degrees has ever been competed for that I know, and I think could not have been, or I should have known it. There is the ordinary B.A. degree and the M.A., which may be given for science or classics in any of those groups of subjects which I mentioned before.

13,183. Are they all equally entitled degrees in arts?—Yes.

13,184. Are there many students in medicine in the College?—Yes, the medical school is very large indeed. I can only speak confidently of those who have attended myself. I had 31 last year; that would represent on an average about the first year's class. The number of individuals attending me in all the classes put together was 54, and the number of medical students attending anatomy and physiology was 73.

13,185. (*Dr. Sharpey.*) Do those consist of both first and second year's men?—They consist of all the medical students in the College.

13,186. (*Chairman.*) Must a candidate for a degree in medicine take a degree in arts previously?—No, he need not. It is required in Trinity College, Dublin; but it was as a substitute in part for the arts degree that experimental physics and modern languages were required from candidates for a medical degree as to some extent an equivalent.

13,187. (*Professor Smith.*) Is the examining body, which conducts the examinations for degrees in Dublin, entirely composed of the professors of the University?—It is, so far as the degrees in arts, law, and engineering, are concerned.

13,188. Is there no external element of any kind in the examining body?—In medicine there is. I presume it was considered that it would not be convenient to take away the medical professors from the sphere of their private practice. The only medical men that do examine *ex officio* are the Professors of Anatomy and Physiology. The others are elected every second year by the Senate of the University.

13,189. Are the requirements for a degree difficult; is it supposed to be a severe degree examination in arts?—Certainly I consider that our standard is fully as high as the Trinity College standard. I was a Trinity College student myself, and I consider that our scale is quite as high.

13,190. It is intended at least that it should be as high?—Certainly.

13,191. Can you state what is the average number of degrees in arts taken in any year in the University?—No, I cannot, but it is considerable. The secretary of the University could easily supply it for any number of years past. They annually print a paper with the list of names on it, which would give the Commission the information.

13,192. To what extent is the instruction in your honours class, for instance, in mixed mathematics, carried?—There is no special course of lectures for the M.A. degree, but I have often expressed my willingness to give one if students would present themselves; there is, however, a difficulty about it, because in most cases the men who take out the M.A. degree in pure and mixed mathematics are men who have obtained Indian writerships, and of course it would be impossible for them to remain in the College, as they have to be present in London; but I have always expressed my willingness to have a separate class in that honour course. The honour course in mixed mathematics for the B.A. degree, is Todhunter's Statics, Tait and Steele's Dynamics, Parkinson's, or Lloyd's, Optics, Godfrey's Astronomy, with parts of Routh's Dynamics of a Rigid Body, and a portion of Newton's Principia. For the M.A., it is the same, with the addition of the lunar theory, a considerable portion of Newton's Principia, with certain sections of the work by Sir William Thomson and Professor Tait, and we had, until lately, also Laplace's Theory of Precession and Nutation.

13,193. In your class of experimental physics have you any means of giving practical instruction to the students?—I make all the leading experiments before the class.

13,194. But you have no means of making the students themselves perform experiments in experimental physics?—No.

13,195. Is there no laboratory arrangement of any kind?—No, there is not. I should be rather unwilling to allow students generally to use many of the expensive apparatus that we have, as they would be difficult to replace if they were injured by being carelessly used. There is, however, a practical chemical labaratory.

13,196. You referred, I think, and also Mr. Townsend, to the scholarships and exhibitions that are given away; how many of them are given away in your

A. H. Curtis, Esq., LL.D.

12 July 1872.

department in each year?—Strictly speaking I have very little to do as Professor of Natural Philosophy with the scholarships at all, because the first year's students of course are examined in business that does not concern my Chair; then for the second year's scholarships they are examined in the business of the first year; and, as those students do not come to me till the second year, I do not examine them either. Again, it was found that the examination for the third year's scholarships interfered so much with the first examination in arts, that it was thought better to dispense with it, and the students who gain a scholarship at the commencement of the second year, are allowed to hold it for the second and third years. So that I have very little to do with the scholarship examinations. The only scholarships for which I examine as Professor of Natural Philosophy are the third year's engineering scholarship, my senior scholarship, and the medical scholarships of the second year; but I may mention that I examine for the first year's scholarships in order to assist the Professor of Mathematics.

13,197. (*Professor Stokes.*) Are those subjects which you have mentioned, such as the lunar theory, precession and nutation, necessary for all who take the M.A. degree in that line?—Precession and nutation has been left out, but it was necessary for years.

13,198. But rigid dynamics and the lunar theory are still requisite?—Yes, rigid dynamics and the lunar theory are an essential part of the honour course. If a student dispensed with that part of the subject, he would do so at his peril, but it would be possible, by very high answering in other subjects, to make up for the omission.

13,199. (*Chairman.*) Are there any additions which you think desirable to make to your evidence?—I think not.

The witness withdrew.

Adjourned to Wednesday next, at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 17th July 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

SIR ROBERT KANE, LL.D., F.R.S., examined.

Sir R. Kane, LL.D., F.R.S.

17 July 1872.

13,200. (*Chairman.*) You are President of Queen's College, Cork?—Yes.

13,201. You are aware that the Commission are concerned chiefly with the course of scientific instruction in the College, but possibly you may wish to make some remarks with regard to the system of instruction adopted in the College generally, and any remarks that you may wish to make on the general subject we shall be very glad to hear?—The Commission is probably already aware, having had some of the professors of the Queen's Colleges before them, that the Queen's University and the Queen's Colleges, which form part of it, were intended for the purposes of the general education of the country, not exclusively for scientific education, or for professional education, but for affording facilities for general university education, including both literature and science. Accordingly, we have in each of the Queen's Colleges a number of professors, and in the Cork College, with which I am connected, altogether, some 19 (they are not exactly the same in all the three colleges), of whom five are specially professors of literary subjects, the classic and modern languages, and history and literature generally, and the remainder are divided amongst the other faculties. We have in the scientific division of the Faculty of Arts in Cork at present seven professors: a Professor of Mathematics, a Professor of Natural Philosophy, a Professor of Chemistry, a Professor of Natural History, including zoology and botany, a Professor of Geology, and a Professor of Engineering; for although that subject is treated as a separate faculty, as there is a special University degree given for it, in the College we consider that the Professor of Engineering always is a member of the Faculty of Arts. Further, the Professors of Logic and Metaphysics, and of Political Economy, belong to the science division of the Faculty of Arts. The departments of scientific education are conducted by the professors by means of lectures and other modes of illustration. The number of lectures given by each professor, and the number of classes which the professor gives, you will find in the report which is laid before Parliament, from which it will be seen that the amount of work done by those professors is very large, and a great deal of it is obliged to be of a rather more elementary character than we should wish, were the circumstances different. There is in Ireland a very great deficiency in the middle-class or secondary schools, owing to which many of the students who enter in the Cork College enter with rather a low standard of preparation. In mathematics, for instance, which is the only scientific subject in our entrance examination, our Professor of Mathematics is obliged to commence his systematic instruction at the point at which he receives the students, and, hence, in the first year in mathematics the teaching is necessarily of a more elementary character than we could wish. That applies also in the literary subjects of the matriculation examination, especially Greek, the preparation in the Irish secondary schools being rather defective in Greek. In Latin the students come to us much better prepared. My friend Professor England, our Professor of Natural Philosophy, who is in attendance, will be able to supply to the Commission more exact information with regard to the scientific departments than I could pretend to give; but in the Parliamentary Report (now submitted) is given, in Appendix F., the reports of the several professors on their special departments for the last session, that is to say, not for the session now closed, but for the preceding session. However, they do not materially differ from one session to another. The report of the Professor of Mathematics is here, and also that of the Professor of Natural Philosophy, but, owing to peculiar circumstances, the report of the Professor of Chemistry is not here. Our Professor of Chemistry died in the early part of last session before he had sent in his annual report. The list of subjects taught by the Professor of Mathematics is given in this report, which the Commission can easily refer to. In the department of natural science we have two special professors, the Professor of Zoology and Botany and the Professor of Geology, and with the permission of your Grace, I shall read the reports of those two professors, as they are not personally before the Commission, and I may be considered in some degree as representing them. The

Sir R. Kane, LL.D., F.R.S.

17 July 1872.

report of the Professor of Natural History for the session of 1870–71 is this. He delivered “One course on Zoology and Botany. The course consisted of 69 lectures and extended over three terms. The first term included eight; the second 12; and the third five weeks of lectures.” The actual number of lectures delivered on natural history was 69, to a class of 59 students, and three lectures delivered each week. “The course included lectures on the principles of zoology and botany, with special reference to the structure and classification of plants and animals. The text-books used were Huxley's ‘Introduction to the Classification of Animals’ and Henfrey's ‘Elementary Course of Botany’ (second edition, by Dr. Masters), Rolleston's ‘Forms of Animal Life,’ Hooker's ‘Students' Flora of the British Islands,’ and (to junior students) Oliver's ‘Lessons in Elementary Botany,’ were also recommended. The lectures were illustrated by means of specimens and diagrams. Herborizations were given during the third term. The professorial method of instruction was chiefly employed. The lectures were attended by students of the third year in arts and of the first year in medicine. Five students in arts, 42 in medicine, and 12 non-matriculated students were present during the course. Of these, eight attended diligently, 46 duly, while five were disqualified for insufficient attendance, and their conduct generally was excellent.” I beg leave to mention that our natural history museum contains a very excellent herbarium for botanical illustration, including a large collection both of European and of foreign tropical specimens; and in the zoology there is a substantially good typical collection of animal forms, both of stuffed skins and of skeletons. To the collection of skeletons the professor, I believe, intends during next year to give some further development, to render it still more complete; but, even at present, I think I may consider that our means of illustration in the natural history department are tolerably satisfactory.

13,202. Were they provided at the Government expense?—Yes; they were provided at the Government expense. There is but one deficiency, however, which I would beg to mention. We have formed in the grounds of the College, which are, however, of very moderate extent, a small garden containing such plants as are useful in illustrating lectures on botany, and on materia medica in the medical school, as will grow in the open air in these countries, but we have no conservatories. We have had no funds available for the purpose, and the Government has never conceded to us the means of erecting a stove-house, in which we could have a collection of such tropical or sub-tropical forms as would render our illustrations of living plants more complete. Our Professor of Natural History has frequently represented the desirability, and I have on his part represented in other reports the importance of such a deficiency being remedied. In this report, which is my report for the year ending the 31st of last March, at page 6, I say:—“I beg leave to represent the necessity already so strongly urged, that a conservatory or hot-house should be provided for tropical and sub-tropical plants to supply typical illustrations for the use of the Professor of Natural History. The urgent want of such has been pressingly urged in former reports, and I again solicit attention to the subject as materially affecting the completeness of instruction in that important branch of science.” That is, I think, almost the only point in which our means of illustration in natural history, or at least in botany, is defective. With regard to geology, I shall give, also in the words of the professor, a description of the arrangements. He says in his report for the session of 1870–71, at page 95:—“The lectures of the Professor of Geology and Mineralogy extended over the three terms of the college session, the first term included nine weeks' lectures, the second 12 weeks', and the third five weeks'. The number of lectures in each week was three, the days being Tuesdays, Thursdays, and Saturdays, and the total number delivered in the course was 74. In the course which embraced physical geography, geology, palæontology, and mineralogy, the following text-books were recommended: Hughes' Outline of Physical Geography; Somerville's Physical Geography; Herschel's Physical Geography; Lyell's Elements and Principles of Geology; Lyell's Students' Manual of Geology; Juke's Manual of Geology; Murchison's Siluria; Owen's Palæontology; and Nicol's Manual of Mineralogy; maps, sections, diagrams, and specimens were used in illustration of the lectures. The form of instruction was professorial, and field exercises in practical geology were given towards the end of the session. The lectures were attended by arts and engineering students. The number of students attending the course was 15, four of whom were arts' students, and the remaining 11 belonged to the department of engineering. The conduct of the students during lecture was highly satisfactory to the professor.” I may mention with regard to the number of students attending this course, that it is only on engineering students that the attendance on geology is compulsory. For the arts' students, geology may be taken as one of a group of subjects for students who wish to obtain their degree in arts in the natural sciences. We have in the Queen's University an arrangement by which the subjects in which the student is to be examined for his degree are to a certain extent specialised. There is a certain common basis in both literature and science, which every student must pass through, but in addition he can take any one of some three or four different groups in which to proceed to his degree. The natural sciences constitute one of those groups, and in the case of a student who goes up for his degree in the group of natural sciences, geology must be attended. Those four arts students that the professor refers to have taken the natural sciences as a group for their degree, in addition to the common basis in which all are examined, and consequently they have to attend the geology course. The professor further says, “As regards fitments and other requirements, and also as relates to cleanliness and accommodation, these are all such as the professor could wish.” Our arrangements for illustration in that department are tolerably complete. We were assisted by a gentleman very eminent in the scientific world here as an amateur man of science, Mr. Greenbough. He had some territorial connexion with the county of Cork, and he presented the College with a very large and beautiful collection of minerals, which has supplied us with the means of illustration in that department in a very complete form. Then we have satisfactory geological collections, of course more particularly relating to the geology of Ireland and of Great Britain. With reference, therefore, to the natural sciences, both in zoology and botany on the one hand, and geology on the other, with the exception of the defect of the absence of any hot-houses or conservatory in our garden, our arrangements, I think, are in a very satisfactory form. With regard to the medical students, and with regard to their forming a large portion of the class of the Professor of Natural History, I would beg to mention that as regards the diffusion of scientific education amongst our students, a good deal is done, not merely with the arts' students, but also with the medical students. The Queen's University in arranging its curriculum for medical education embraces in that curriculum a considerable amount of literary and scientific instruction, more than what is usually contained in medical studies, and by that means has been able to diffuse scientific instruction amongst a large class of students—a class, who constitute rather more than one half of the whole body of students attending the college.

13,203. Do you mean to say that more than one half are medical students?—Yes, rather more, about 53 per cent. of our total number. In our last session the total number of students in the college was 263, of whom 243 were matriculated students, that is, students proceeding

Sir R. Kane, LL.D., F.R.S.

17 July 1872.

for degrees, and the remaining 20 were non-matriculated students, who are students that enter only for the lectures of a particular professor in a particular subject to which they wish to devote themselves, but who are not proceeding for a university degree. Out of the 243 matriculated students 154 were in the faculty of medicine. Those students, however, in the faculty of medicine pass in the first instance the same matriculation examination as do the students in arts; they are examined in Latin, in Greek, in mathematics, in English, in arithmetic, and in geography, just as the students in arts are. Afterwards they have to attend instruction by lectures, and otherwise, in a modern language, and for that practically they always select French. They may select either French or German or Italian, but practically the medical students have always selected French, so that we have a special class of instruction in French which goes by the name of the Medical French Class, in which the professor for teaching that language uses books having certain relation to medical subjects, the biographies of eminent medical or scientific men, and other books of that kind, which should have a more special interest for the medical students. Then they also must attend the course of zoology which is given by the Professor of Natural History, and which is not usually contained in medical studies, for medical students usually limit themselves so much to human anatomy that a course of general zoology, particularly philosophical zoology, at least in Ireland, scarcely exists as a part of medical education, except in the Queen's Colleges. In the faculty of arts in the last year there were 53 students; in the faculty of medicine, 154; in the faculty of law, 11, and in the faculty of engineering, 25, making 243.

13,204. Is the matriculation examination of which you speak an university examination or a college examination?—It is a college examination. It is held in the colleges, and its amount is determined by the College Council; but the names of the students who have passed the entrance examination in the colleges are all forwarded to the secretary of the University, and they are all enrolled upon the book of the University as students of the University. In that regard I would beg leave to mention to the Commission that I cannot precisely concur with my distinguished friend our Vice-Chancellor, Sir Dominic Corrigan, with regard to the explanation which he gave in the correspondence with the secretary to the Commission that the Queen's University was not a teaching University. We, who are specially connected with the Queen's Colleges, do regard the Queen's Colleges as being part and parcel of the University, and that the University is a teaching University through its colleges, just as much as any University in Great Britain is. In the charter of the Queen's University, in the 10th clause, which I beg leave to read; it is stated, “ And we do hereby “ further direct and ordain that Queen's College, “ Belfast; Queen's College, Cork; Queen's College, “ Galway; and such other college or colleges as may “ hereafter be founded by us, our heirs or successors, “ under and by virtue of the provisions of an Act “ passed in the session of Parliament holden in the “ eighth and ninth year of our reign, and intituled, “ ‘An Act to enable Her Majesty to endow new “ ‘colleges for the advancement of learning in Ire- “ ‘land,’ shall be, and they are hereby constituted, “ colleges of the University, and all professors of the “ said colleges shall be professors of the University; “ but the said colleges shall not be in any way under “ the jurisdiction or control of the University Senate, “ further than as regards the regulations for qualifi- “ cations for the several degrees, or other University “ distinctions, the said colleges being in all other “ respects subjected only to the charters and statutes “ issued and approved of, or to be issued and approved “ of by us, our heirs or successors, for the Govern- “ ment of the said colleges respectively.” That is to say, the Colleges have reserved to them under their own charters their entire internal government as to administration and discipline and all internal material arrangements, but they are entirely subject to the University with regard to the general direction of their systems of instruction for degrees; and the professors of the Colleges are specially constituted University professors and the Colleges University Colleges; so that we regard and have always regarded the Colleges as simply the teaching instruments of the University, and that the University, therefore, although there is no Queen's College in Dublin, although the University at its head quarters or heart in Dublin has hitherto remained without any special buildings owing to the peculiar circumstances of the country, still the teaching organisation is quite complete, and is carried out in the provincial colleges entirely under the direction of the University by professors who are University professors. And, therefore, I must beg leave to say that I consider that the Queen's University may be regarded quite as much as the University of Edinburgh or the University of Oxford or of Cambridge to be strictly and properly a teaching University. We attach some importance to that question as between the relative position of a teaching University and an University which is merely an examining body for giving degrees to anyone who presents himself; that is a question which at present is attracting a great deal of attention, and it has always appeared to us one of very vital importance to the proper sustainment of the standard of university instruction.

13,205. Do you consider the Queen's University to be in a greater degree a teaching University than the University of London?—Much more so.

13,206. The Senate has to a certain extent a control, has it not, over the system of teaching in the Colleges?—The Senate directs in general terms the instruction that is to be carried out; it directs what they require for their degrees, but they leave to the councils of the individual colleges the carrying out of the details; the arranging, for example, of the number of lectures that each course is to consist of; the number of lectures that are to be given weekly, and so on. Of course much is left to the individual professor, subject to the supreme responsibility that if he were found to have neglected any important portion of his subject he would be liable to be called to account for it by the College Council in the first instance, and by the University Senate afterwards; but subject to that, the supreme direction of the education is by the Senate. The colleges are Colleges of the University, not as in the London University where the degrees are given to any person who presents himself, and who chooses to pass through certain examinations without reference to whether he has ever gone through any really educational course in a collegiate institution or not.

13,207. The final examination for all degrees is conducted by the University itself in Dublin, is it not?—Yes, it is held in Dublin. There are two examinations necessary for students proceeding for degrees. There is one which is the first examination in each branch for a degree, and which, until within the last 12 months or so, used to be conducted in the colleges, by the University Professors, however, and on papers sent down from the University, but it has been now arranged by the Senate that even for the first University examination the students must all proceed to Dublin, and be all examined there. That has been found more conducive to the proper conduct of the examinations, and on the whole to the convenience of the students themselves, so that at present all the University examinations, both the first examination and the final degree examination, are held in Dublin, and in the colleges there are now held only the entrance examination for students who present themselves for the first time, and the class examinations at the end of the session. At the end of each session every professor examines the students of his own class or such as choose to present themselves for honours and prizes. In the faculty of arts, and in the faculty of engineering, all must pass what we term the sessional examination in order to be promoted to the rank of students of the subsequent year, so as to be enabled to proceed with their study. A student, for instance, who has passed his first year in the faculty of arts, cannot become a student of the second year, unless he has passed in the sessional examination at the close of the first year, and that is done in the College.

13,208. He loses a year if he does not pass? — If he did not pass he would be thrown back and have to resume the studies of the first year. The sessional examinations for promotion are conducted very strictly indeed, and in my report I state the results of the College examination for sessional promotion of students for the session of 1870–71 :—" The " examinations for sessional promotion were held at " the end of the session 1870–71, with the result " shown in the folowing table." In the faculty of arts out of a total of 50 students, 23 were promoted, and 27 were not promoted. Those 27 may have failed only in a single subject; they may have been examined in seven or eight different subjects, but they may have failed only in a single subject, and in such a case we allow the student to pass next session, what is called a supplemental examination in a special subject. He has the long vacation to work it up, and if he passes the supplemental examination in October, we then allow him to go on. In the faculty of law there were nine students, of whom five were promoted and four were not promoted. In the faculty of engineering, out of 30 students, 14 were promoted and 16 were not promoted, so that of 89 students, 42 were promoted and 47 were not promoted, but a large number of that 47 would get in in October by means of the supplemental examination. The medical students do not require any form of promotion of that sort, for the medical students are only bound by our statutes to attend one year in one of the Queen's Colleges. We were obliged, in consequence of the very loose state of medical education generally in the country, to allow in the Queen's University that students should carry on their medical studies at any medical school that they might like, subject to spending one year, out of the four years which their medical course must embrace, in one of the Queen's Colleges, and in addition to what they may do in that year, they must attend in the Queen's Colleges, the subjects of natural philosophy and modern languages; so that is the amount of connexion which the medical school has with the actual system of University instruction. To the students who distinguish themselves at those examinations, those who answer best in their special subjects, there are class prizes awarded which are conferred by the College Council: they are very small prizes, sometimes 3*l.*, and sometimes only 1*l.*, according to the degree of merit of the answering, and are given not in money but in books.

13,209. What rewards are there in the way of scholarships?—In the Cork College, and I believe it is exactly the same in the others, we have alogether 54 scholarships, the values of which vary from 20*l.*, which is the value of an engineering scholarship, to 40*l.*, which is the value of what we term a senior scholarship. We have 30 junior scholarships in the faculty of arts, eight scholarships in the faculty of medicine, five scholarships in engineering, and four scholarships in law; and then we have in the faculty of arts seven senior scholarships, which are conferred for special subjects on students who have attained the degree of Bachelor of Arts, and who are proceeding to the degree of Master of Arts. Those seven senior scholarships are distributed amongst the subjects in a manner which I shall be able to state to the Commission. There is one senior scholarship appropriated to ancient languages, literature, and history of ancient Greece and Rome. One to modern languages, literature, and history, viz., English language, literature, and composition, European and English history, and the French language, with German or Italian. The French language is necessary, but there is an option between German and Italian. With regard to that I may mention that with us modern languages includes English, which very often is not the case in this country, and we are extremely particular about our teaching of English, perhaps because it has to us somewhat the charm of a foreign language; but our Professor of English delivers a course of instruction in English grammar and etymology, and on the history of the English language, from the Anglo-Saxon down to the present day, which I really think it would be difficult to get equalled in this country. The history of language, its successive developments, and its modifications according to the various circumstances of society, are really taught in Cork College in a manner which I think it would be difficult to have surpassed, at least over here; so that in classing English as one of the modern languages in which a senior scholarship is given, it is really that we do treat English as a serious subject of study. Then we have a senior scholarship for mental and social science, including logic, metaphysics, and political economy. There is one senior scholarship in pure mathematics; one senior scholarship in natural philosophy, including experimental physics, and mixed mathematics; one in chemistry, including both theoretical and practical chemistry; one in natural history, including zoology and botany, geology, and physical geography; and one senior scholarship is devoted to the faculty of law. Consequently, in relation to the special subject of this Commission, we have four senior scholarships specially available to students who devote themselves to the higher cultivation of mathematics, physics, chemistry, and natural history. In our junior scholarships in the faculty of arts we also make a distinction between a literary scholarship and a science scholarship. We have, as I have mentioned to the Commission, 30 junior scholarships in arts. Our course in arts embraces three years, so that is 10 scholarships in each year, and of those 10 scholarships which are awarded in each year to the arts' students, five are awarded after an examination in literary subjects, which includes Latin, Greek, and one modern language, and five are given in mathematics. However, Professor England will be able to tell more accurately what is done in the third year. The second and third years go together, and include only mathematics, so that the junior science scholarships are mathematical scholarships. It is only in the senior scholarships that there are special scholarships for physical and natural science. The average value of scholarships is 26*l.*, the maximum and the minimum being 50*l.* and 20*l.* respectively, and the average is 26*l.*, tenable for one year. That is the total amount of funds available. But in practice the scholarship examinations are very rigidly conducted; in fact, we may claim that whatever we do in the way of education in the Queen's Colleges is *bonâ fide* done, and in those examinations, as you will have seen by the results of the sessional examinations, there was not one half of the students promoted at first. Similarly the scholarship examinations are very rigidly conducted, and the number of scholarships actually conferred is always very much short, even of the very moderate amount that is available. I happen to have thrown together, for an entirely different object, some memoranda, from which I would beg leave to mention the results of the scholarship examinations for the last five years, from 1866–67 to 1871–72. It is this, that in the faculty of arts the total number of scholarships available was 185, that is including both senior and junior scholarships taken altogether, and the number awarded was 129, or 69½ per cent. short of 73 per cent.: in the faculty of arts, there were thus only seven-tenths of the scholarships conferred. In the faculty of medicine, out of 40 scholarships available, in the five years there were 35 conferred. In the faculty of engineering out of 25 available 22 were conferred, and in the faculty of law, out of 20 that were available 19 were conferred, and the total result was out of 270 scholarships 205 were given, or it may be taken as 76 per cent. of the scholarships. Those 270 scholarships in the five years were competed for by 1,190 students, which gives an average of about five students competing for each

Sir R. Kane, LL.D., F.R.S.

17 July 1872.

scholarship. It is sometimes said in Ireland that the Queen's Colleges get their students by a system of bribery carried on with Government money, but there you have had within the last five years a body of 1,190 students, and yet of the 270 scholarships offered there were only 205 granted at an average value of 26*l.*, after a competition, which, considering the age and position of those young men, I must say, is certainly a very difficult competition.

13,210. Do those figures apply to the Cork College?—Yes.

13,211. The senior scholarships equally with the junior scholarships are College scholarships?—Yes.

13,212. And not competed for by students from different colleges?—No.

13,213. Are there any scholarships competed for by candidates from the different Queen's Colleges?—Such rewards are not termed scholarships at the University; they are termed University honours; and, also, there is a certain class that are known by the name of Peel Exhibitions. When the present Sir Robert Peel was Chief Secretary for Ireland, he organised a subscription, by means of which some 6,000*l.* or 7,000*l.* was collected, which was invested, and produced a fund from which certain exhibitions are paid, which are given to the students, at the degree examinations, who distinguish themselves in the different branches in which degrees are given. These are students who take their degrees with first or second class honours. At the University examinations a degree may be taken with first class honours, with second class honours, and with third class honours, or, finally, a student may get his degree unclassed. There is generally a small money reward, about from 5*l.* to 10*l.* given. I believe it is 10*l.* for the first class honours, and 5*l.* for the second class honours, to students who get their degree with those honours. Also, a student who gets his degree with first class honours gets a gold medal, which is of very little intrinsic value, and a money reward, which is generally 10*l.*; the student who gets his degree with second class honours gets a money reward, which varies from 5*l.* to 10*l.*, but he gets no medal; whereas in the case of the student who gets his degree with third class honours his name is merely mentioned in the University list as having passed with third class honours, but he gets no reward. Then the students from each College who get their degree with high honours are entitled to one of the Peel Exhibitions, which generally is about 20*l.*, held for one year or two years according to circumstances.

13,214. Are all the examinations, both of the College and the University, conducted by the professors?—All except the medical examinations. They are not conducted by the college professors as college professors, but as University professors,—the three professors in each branch of science or letters, for instance, the three Professors of Chemistry or the three Professors of Mathematics form a board of examiners, and the examination papers are prepared in common, a portion of the papers being prepared by each professor. Then the students are examined on those papers, and the value of the answers is judged by the professors conjointly, acting together. By that means it was considered that two difficulties would be got over. First, that any jealousy or suspicion of favouritism amongst the Colleges would be got rid of; and, secondly, that the danger of the examination taking a one-sided turn, owing to the peculiar tastes or the peculiar line of study of a certain professor, would be obviated by having a portion of the examination paper prepared by each professor. It might happen, for instance, that the professor in Belfast would take a line in metaphysical teaching, or even in mathematical teaching, which the students in Cork, for instance, having had a professor of a different turn of mind, might not have been properly prepared in. If, for instance, the Mathematical Professor in Cork were devoted to purely geometrical methods, and the professor in Belfast to purely analytical methods, it might not be quite fair to examine the students of the one college by the professor of the other; but where the professors are associated with one another, of course that difficulty is got over.

13,215. Has the system of conducting examinations worked satisfactorily?—Very satisfactorily. In the case of the medical courses of anatomy and physiology, which are treated in Queen's College very much as biological sciences, very much as sciences which, although principally associated with medicine, are not entirely and purely medical sciences, anatomy and physiology are examined into by the three professors in the three Queen's Colleges, united in the same way as with the literary and scientific subjects, but in the case of practical medical subjects, in the case of the practice of medicine, the practice of surgery, midwifery, materia medica, therapeutics, and medical jurisprudence, the University Senate reserve to themselves the power of appointing any examiners that they wish, and generally speaking they appoint some of the most eminent Dublin men from the Dublin medical schools to examine. They consider that they probably get a somewhat higher class of medical practitioners from Dublin than they could get from merely provincial towns, and also remove the suspicion of partiality in the professors examining their own pupils. For the special medical departments they have only one examiner in each topic; they have not a board of examiners, as they have in the arts faculty and in the engineering faculty. In the case of medical jurisprudence, to which I have referred, we have in the Queen's Colleges no special professor of medical jurisprudence. At the time that the Queen's Colleges were founded there was not at all the same amount of public attention given to medico-legal matters, and to sanitary matters, and to questions of public health, and so on, which there is now, and there was no professorship founded. Each college has thus made its own arrangements for teaching medical jurisprudence. In the Cork College it has hitherto been done by association. Our Professor of Law and our Professor of Chemistry have divided the course of medical jurisprudence between them; the Professor of Chemistry, who was also a doctor of medicine, taking all the toxicological portion of the subject, the detection of poisons, and purely medical subjects, insanity and such like, and our Professor of Law then taking up the subject in all its legal aspects. By that means we have had the subject done in Cork in a very complete manner; but we have been so unfortunate last Christmas as to lose our Professor of Chemistry, Dr. Blyth, whose death was a very serious loss to the College, and we shall consequently in the next session be obliged to make some different arrangement, at least so much of a new arrangement that I could not at the moment say precisely what it is likely to be. Hitherto the medical jurisprudence has been very well taught in the way that I have described, but if it will at all come within the scope of this Commission as regards the point of view of public health and the administration of justice, to notice such a subject, I would beg leave to represent that it would be very desirable in each of the Queen's Colleges if a special professor of medical jurisprudence were added to the body of the teachers, for I need not remind this Commission how vastly important that subject is every day more and more becoming.

13,216. Do you know whether a professorship of that description exists in any University in the United Kingdom?—At Dublin there is in the Royal College of Surgeons a Professor of Medical Jurisprudence, and also a Professor of Hygiene, and in Trinity College there is a Professor of Medical Jurisprudence. These are not strictly University professors, but the latter lectures in the University school. There is also a Professor of Medical Jurisprudence at the University of Edinburgh. As regards London, there is at University College a Professor of Medical Jurisdiction and one of Hygiene, and at King's College one of Medical Jurisprudence.

13,217. Are the professors provided with any assistants in conducting their departments?—That is a matter in which we are somewhat deficient in Cork.

Sir R. Kane, LL.D., F.R.S.

17 July 1872.

I am not able to speak with respect to the other Colleges in that regard, but in Cork the College pays an assistant for the Professor of Chemistry, and in the anatomical school we have demonstrators who are, however, paid, not by the College, but by the Professor of Anatomy. The College places the department of anatomy and physiology altogether in the hands of the professor who is responsible for its being properly taught, and then he employs demonstrators of whom he has hitherto had two. Then the Professor of Natural History has the head gardener, who is a very good botanist, and quite capable of arranging everything connected with the preparing of the botanical lectures and supplying specimens, and so on, and who in that regard may be considered as a kind of botanical assistant, but of those whom we recognise as assistants the Professor of Chemistry has the only one. It would be very desirable indeed if there were an assistant in the department of natural philosophy. Professor England will be able to say more with regard to that, but even from my own general knowledge of the requirements of that department, the amount of personal work and the amount of actual drudgery that is thrown on the professor by his being obliged, without assistance, to make all the arrangements for experimental illustrations is very great, so very great as almost to render it impossible, or at least extremely difficult, for the professor to get through it as a mere matter of time and labour, quite precluding him from the amount of leisure which may be required for anything like original investigation or research. With regard to the department of chemistry it is my duty to mention the arrangements to the Commission, because from peculiar circumstances, we could not be represented here by our Professor of Chemistry. As I have already mentioned, we were so unfortunate as to lose Dr. Blyth last Christmas, and we were then a couple of months without any professor, during which time we made the best provisional arrangements we could for carrying on the instruction: since then Dr. Maxwell Simpson, whose name is probably known to some members of the Commission, was appointed, but at so late a period in the session that he could not consider himself sufficiently familiar with the college arrangements, or with what had been the arrangements of the department, as to completely represent it; and in addition he is at present himself suffering from illness, so that he is not in a condition to attend here. Owing to the death of Dr. Blyth also the report is unfortunately defective in that regard, as there is no report of the chemical department. Dr. Blyth had not sent in his report at the time of his death, and we were consequently not able to get it. But the course of lectures in chemistry consisted generally of about 70 or 75 lectures delivered during the session, which generally lasts about seven months; the full course of lectures in the faculty of arts lasts about seven months. The college session lasts eight months, but the first fortnight and the last fortnight are occupied by the examinations, so that the lectures may be considered, with short interruptions by holidays at Christmas and at Easter, to last seven months. The ordinary course of lectures includes from 70 to 75 lectures, and those are very fully illustrated by experiments. Dr. Blyth was a gentleman whose knowledge of the subject was kept up in an extremely perfect manner, and he spared no trouble in arranging and illustrating his lectures in the most complete manner, so that that department was always very well conducted indeed. Then there is an excellent laboratory at Cork, which was constructed under his direction. Dr. Blyth had been our professor from the commencement; he was appointed at the first opening of the College, and the laboratories were constructed under his own direction, so that they are in a very complete form, and we are in that department, I may say, very well represented. Then he had a practical class which worked in the laboratory; he delivered practical demonstrations to that class, and there was additional work to individual students at testing, at elementary research, and at analyses of various kinds, analyses of manures, analyses of pharmaceutical products—the preparation of pharmaceutical products and the various operations of pharmaceutical chemistry—all that Dr. Blyth arranged for his class, and he himself devoted very great attention to toxicological research, both in reference to his portion of our lectures in medical jurisprudence, and also he had been selected by the the Government for conducting any investigations as to poisoning or as to medical jurisprudence that might occur. He had attained a considerable reputation both as a chemist and as a toxicologist, and he consequently was, generally speaking, and, I may say, always, employed when prosecutions for poisoning were directed by the Government. In that way his practical chemistry arrangements took a direction which made them extremely interesting to the medical portion of his class. We may, therefore, consider that our chemical department in Cork, certainly up to the period of Dr. Blyth's death, had been, and I am quite sure in the future, under the management of Dr. Maxwell Simpson, will be kept in a very creditable manner.

13,218. (*Professor Smith.*) Do I understand you that there is but one assistant to aid the Professor of Chemistry in the practical teaching of the laboratory as well as in his lectures?—Only one; there is a laboratory porter also.

13,219. But there is only one skilled chemical assistant to assist in the preparation of the lectures, and in the instruction in the practical classes?—Only one, and he is the only assistant whom we are enabled to employ, owing, I may say, to the very limited amount of the funds which we have at our disposal for those purposes.

13,220. Are all the students in the faculty of medicine required to attend practical courses of labatory instruction?—They all must attend practical chemistry for their degrees, but they are not bound to attend practical chemistry in the Queen's College. They may attend practical chemistry in any other medical school if they wish. They are only obliged to attend one year in the college; they may get the rest of their instruction elsewhere.

13,221. (*Chairman.*) I think I understand you to say that the medical students are obliged to pass the ordinary matriculation examination?—Yes.

13,222. Is Greek compulsory?—Yes, Greek is compulsory.

13,223. Then no medical degree can be conferred without a knowledge of Greek?—Not without some knowledge of Greek. Of course the amount of Greek that we can enfore at a matriculation examination cannot be very large; but still the students must at least have some knowledge of the Greek language.

13,224. Does that apply to all students at the colleges; must they all pass an examination in Greek?—Yes, all except engineering students. I will read a passage from our College Prospectus, which is given in the appendix to my report:—"Matri-" culation examination. The subjects in which can-" didates will be examined are these: for the " faculties of arts, medicine, and law: Greek " grammar: any one of the following authors which " the candidate may select: *Homer*, Iliad, Books I. " and II.; *Xenophon*, Anabasis, Books I. and II.; " *Lucian*, Walker's Selections." He is examined in Greek grammar, and then he is examined in anyone of those three books, Homer, Xenophon, or Lucian, which he may select. Then "Latin; any one of the " following authors which the candidate may select:— " *Virgil*, Æneid, Books I. and II.; *Sallust*, Conspiracy " of Catiline; *Cæsar*, Gallic War, Book I. In English " grammar, (1), the principles of etymology and " orthography; (2), the leading rules of syntax, com-" position and writing from dictation; outlines of " Grecian history to the death of Alexander the " Great; outlines of Roman history to the accession " of Augustus; outlines of ancient and modern geo-" graphy. In mathematics: *arithmetic*, principles of " notation; vulgar and decimal fractions; definition " of the terms ratio and proportion. The rule of

Sir R. Kane, LL.D., F.R.S.

17 July 1872.

" proportion, with its commercial applications, in- " cluding simple interest. *Algebra*: explanation of " the signs and meaning of an index. Calculation of " the values of algebraical expressions, when parti- " cular values are given to the letters which they " involve, *Euclid*, book I, with the definitions and " axioms." For the Department of Civil Engineering the classical languages are omitted from the matriculation examination. For civil engineering, they have English grammar, and the outlines of modern geography; and in mathematics, "*arithmetic*, prin- " ciples of notation; vulgar and decimal fractions, " with the reasons of the different rules. Rule of " proportion, with its commercial applications; ex- " traction of the square root, both of whole numbers " and decimals. *Algebra*: explanations of the signs " and meaning of an index. Calculation of the value " of algebraic expressions, when particular values " are given to the letters which they involve. Euclid, " Books I., II., III., IV., and VI., with the definitions " of Book V." There is a larger proportion of mathematics required from an engineering student, but he is relieved from the classical languages. That is the amount of the matriculation examination, and the College Council would be very glad to increase it if the condition of the country with regard to the schools justified them, for the professors, as they have to begin at the point at which the students enter, would then be enabled to give a higher tone to their instruction, the students being enabled to come into the college better prepared. It is a sound matriculation examination as it stands now.

13,225. At what age do the students generally matriculate?—The average age is about 16 or 17; a few students of some precocity of intelligence enter more early than we should wish; some enter at 14 years of age, but very few. For instance, out of 77 new students who entered last October there were two that entered at 14, then at 16 and 17 years of age 14 entered at each age, at 18 years of age 10 students entered. The greater number of medical students enter at an older period. They may have been a couple of years at the profession before they matriculated in the college, or they may have been at another medical school for a couple of years before they go to the college, so that a medical student is often 20 or 21 before he appears on our roll as a matriculated student, but the average age of entrance would be about 17.

13,226. Are there any additions which you would wish to make to what you have now stated to the Commission with respect to the Queen's College course?—There is one matter which has always been a subject of regret to me, and which I have not yet referred to, which is the very small amount of money which we have been enabled to appropriate to the different scientific departments for providing them with the material of teaching. We have done our best with the funds that were at our disposal for providing apparatus, and illustrations of all kinds, but we have been obliged to do it with such parsimony, I may say, that we are possessed only of the material that is absolutely indispensable for anything like proper teaching. We have no pretension to anything like the luxuries of illustration with which you are familiar here in London, and in the English Universities. Although, of course, we could not pretend to anything like the brilliancy of the collections that are here, yet it would be very desirable if we were enabled to do something more than at present is in our power. The whole sum at the disposal of the college for the support of all its departments from year to year, I mean independent of the salaries under the endowment from the Consolidated Fund, is 1,000*l.*, which is annually voted by the House of Commons, for each of the Queen's Colleges. That has not merely to support the different literary and scientific departments, but it has also to provide for all the establishment charges of the college with regard to its administration, and that amount in the last year, for the year ending the 31st of March last, came to about 550*l.* Those establishment charges consist in printing, stationery, and advertising, in taxes for water, and various other expenses which the college has to pay, in clothing for the porters of the college, in incidental expenses of various kinds, in the heating and lighting which is every year becoming a heavier expenditure, and in the maintenance of the botanical garden, or rather the grounds of the college, independently of the actual teaching use of the garden. In the last year all these things took up 550*l.* out of the 1,000*l.*, and estimating it at 500*l.* out of the 1,000*l.*, which is its minimum certainly, there remains for the whole of the scientific and literary departments only 500*l.* That is a sum which would appear to the Commission, I am sure, ridiculously small, when it is considered that there are four great literary departments to be conducted, and collections of books to be kept up in a satisfactory state, besides the several scientific departments.

13,227. (*Professor Smith.*) Does that include the library?—Yes, it includes the library. Our expenditure in the last year on the library of ancient and modern languages was 128*l.*, that includes Latin and Greek as the ancient languages, and it includes amongst the modern languages, English, French, Italian, German, and representations of some of the less important languages, the various Sclave and Romance languages, and some Indian languages, because we are very anxious that our literary department should not merely have a nominal or an old-fashioned classical existence, but that our library and our instruction in literature should really represent the literary movement and literary progress of the present day. Although our library altogether is only small, for we have about 20,000 volumes, yet there is not a volume out of the 20,000 that has not been got for a special purpose, and to meet a specific requirement, so that there is not a volume in it either too much or out of place. Our representation of continental literature is tolerably complete. Then with reference to sound historical or philological culture no books are bought without a specific object; but, however, that, of course, each year takes a certain sum, and when that sum for last year was only 128*l.* it will certainly not appear excessive. Then for the mathematical and physical sciences, including chemistry, we have got during the last year only 115*l.* However, that was rather exceptional, owing to the peculiar circumstances of the chemical department. The death of Dr. Blyth and the late date of the appointment of Dr. Maxwell Simpson caused the chemical department to be almost suspended during the last session, and the expenditure on it was very trifling. In zoology, botany, and geology the expenditure was 74*l.*, which, however, was practically not a large one, because we did not happen to buy any amount of specimens, or to add anything to our collections last year. Another year we might have a larger expenditure on that head, and some other department would remain in abeyance for the time. In the medical sciences there was 94*l.* 5*s.* laid out, of which 75*l.* 6*s.* 6*d.* was for books, and 18*l.* 18*s.* for apparatus. I may mention that we are not so well provided with regard to medical collections, with the exception of anatomy and physiology. Some years ago there was a fire in Cork College (whether it was accidental or intentional we were never able to decide), and one portion of it was burnt down, and unfortunately that portion included two collections which were very complete, our pathological collection and our materia medica collection. We have never since been able to meet with an opportunity of replacing in a complete manner either the one or the other, but we shall of course avail ourselves of every opportunity that presents itself. In the Materia Medica Museum we were very unfortunate, for we had purchased the collection of Dr. Anthony Todd Thompson, who was very well known as a distinguished author on materia medica in this country. It was in some respects an extremely interesting collection: it contained the whole of the collection of Cinchonas of Bonpland from South America, which he had sent home to Paris in a French vessel, which was taken by one of our cruisers, and the collection was presented by the then governmental authorities to Dr. Anthony Todd Thompson. We got that collection amongst his museum, but they were all lost by that fire. I mention that as a reason for the medical department in this year not having got probably what would be their proper proportion of the fund. But the whole amount available for the literary and scientific professional departments may be taken as certainly not exceeding 500*l*. We, therefore, have no means whatever at our disposal for advancing science. All that by any possibility we can pretend to do is, so far as our means allow, to represent to the students the actual condition of science, but we have no means whatsoever by which we could pretend to advance it.

13,228. (*Chairman.*) Was the college at its original establishment provided with a library and other collections?—Each of the Queen's Colleges at their original establishment obtained a special grant of 4,000*l*., which was for the purpose of furnishing an immediate outfit. About one half of that was appropriated to the purchase of books, and the remaining 2,000*l*. to the outfit of all the scientific departments. Then, for some years after that, the colleges got a grant to each college of 1,600*l*. a year; but when that had gone on for some years the Government thought that the different departments ought to have been pretty well supplied by that time with their stock of books and apparatus, and they diminished the grant of 1,600*l*. to 1,000*l*., and it has remained at 1,000*l*. ever since.

13,229. Are the buildings themselves kept in repair by the Government?—They are kept in repair by the Board of Works. The buildings and all the internal fitments, and all the materials, I may say, indeed, all the property of the college is by the Treasury considered to be vested in the Board of Works; so that in fact the educational staff of the college has rather the permissive use of the college than the actual ownership of it in the proper sense of the words.

13,230. (*Professor Stokes.*) I am aware that you are an original investigator, and I think it is possible you may have turned your attention to the relations of the State to science. Have you considered what the State ought to do towards its promotion?—Yes, to some extent; I have frequently thought over the way in which, at least the department of science which I am personally conversant with, could be advanced through the assistance afforded by the State.

13,231. Can you give the Commission the benefit of your opinion upon that subject?—The conclusion that I have come to is, that the great difficulty to be overcome is to obtain for the cultivators of science time for carrying on original investigation. Practically, the only time during which a man of science can really cultivate science with a view to its progress, and with a view to research, and adding new facts to science, is before he gets any public position, when he is very little more than a student, and he cultivates science and prosecutes research with more or less success, really almost more as a means of attracting notice and acquiring reputation, which may lead him to some appointment, to a professorship, for instance, in one of the Queen's Colleges, or in one of the institutions in London. But as soon as he does get one of them he becomes so occupied with his lectures and with science, considered as a matter of business occupation, that no more time remains at his disposal for the cultivation of abstract science. Take the case of our special scientific professors, our Professor of Mathematics, or Professor of Natural Philosophy, and consider the number of lectures that they have to give in the week. Our Professor of Mathematics in Cork delivers 14 lectures in the week, and he lectures to three distinct classes, owing to the different standard of acquirements of the students, and owing to the different objects with which the students are carrying on their studies, according as they are students in arts or as they are students in engineering. He is obliged to subdivide his mathematical class into a number of smaller classes, and to lecture to them at separate hours on different branches of mathematical science. That takes up a considerable amount of time, but in addition to that there are other duties that devolve upon him. There is the administration of the College by the Council, which is composed of six professors, and necessarily, the leading professors are pretty sure to be elected members of the Council, which takes up a certain amount of time. The Professor of Natural Philosophy, Mr. England, who is here, delivers 12 lectures weekly similarly, for he has three or four classes. And we must take into account the time required for preparing for those lectures, which are all experimentally illustrated, and the time taken up in preparing examination papers, and in conducting examinations. These matters all absorb time. I am aware that here, in London, at least in chemistry, which is the subject with which I am most familiar, a person who has any reputation gets an amount of private consultative business, which for his own personal interest of course he cannot neglect, and which occupies the time so as to leave no room whatsoever for original investigation. It has always appeared to me that the great object, with regard to the advance of science, would be to place the men who had given proofs that they were men who could advance science, in a position where they really could devote a certain amount of their time without disturbance to that object. To effect that I think the proper course would be to relieve them from a great deal of the mere inferior work of preparation for the lectures and doing an amount of mere porters' work, as it were, the work of a mere assistant, which can be done as well or even done better by very inferior men. I recollect my friend, M. Dumas, of Paris, the eminent chemist, saying to me that it was quite a proverb in Paris that a good préparateur was a bad professor,—*bon préparateur mauvais professeur:* that the two classes of persons were totally different. Consequently by providing a class of assistants or preparators who should get ready the apparatus, and who could arrange the proper tests, and do all that detailed drudgery of the work of which every department requires a great deal, by that means the actual professor, whom we may suppose to be a man of certain eminence in science, should have time at his disposal, and his lectures would acquire a great deal more authority with his classes by being known to be himself a person of mark and position in the world of science, than if he were a mere parrot repeating what other people had done. I have often heard students saying, Oh! we can get that a great deal more satisfactorily by the simple reading of treatises upon the subject; he can tell us nothing but what is in the treatise. But in the case of a man who is himself an authority on the subject, and who is himself known to the students as an individual who has made such and such discoveries, his instruction would carry with it not merely an amount of authority, but would have an energy and should communicate an energy to the students which the teaching of a mere routine lecturer could never in any way give. I think, therefore, the key to giving an impulse to the cultivation of science by persons of the professorial class would be to relieve them from the mere drudgery of the preparatory work by providing them with a proper amount of assistance, and that is precisely the point in which we are most deficient in the Queen's Colleges, at least in the Cork College. We have simply in his department, as Professor England will be able to tell you, the physical apparatus that is absolutely indispensable for his lectures; but we have none outside of that, and it would be nearly useless in fact to have a complete physical laboratory with an extensive physical collection, for it would be quite impossible for Professor England himself to make use of them or to manipulate them or to work with them without assistance. He has no assistant, and the formation of what ought certainly to exist in an University College, a complete

Sir R. Kane, LL.D., F.R.S.

17 July 1872.

physical cabinet with its accessories for practical experimental work in physical problems and physical research would be useless, unless there were proper assistance to carry the thing on. There is, therefore, as far as I can judge, no means by which science could be more effectively promoted than by a proper amount of that class of assistants who would leave the actual professor free for the higher department of his work. For instance, in the mathematical department, such an assistant would have the invaluable effect of being able to take up the junior students at a point where it is really cruel to a professor to have to descend to meet them. For instance, we have had in Cork, successively, several professors of mathematics. We had originally Professor Boole, with whose name you are familiar, and we since have had gentlemen who were both senior wranglers and Smith's prizemen at Cambridge ; and to imagine those gentlemen condemned to go down and teach our students the nature of simple equations, or the third or fourth book of Euclid, is really cruel. And if there were a mathematical assistant who could take charge of the more elementary instruction of the students, and do what ought to be done by the schools, but which is not done by the schools, at least in Ireland, and hand the class over to the professor when they become really fit to enter upon the more advanced subjects, that I think would enable the professor to do a vast deal more in the higher department of teaching, and also to devote a greater amount of time to the development of original inquiry in mathematics. We attempt it to some extent by means of our senior scholars. Whenever we can get a senior scholar to remain in the college during the year in which he holds his scholarship we employ him. If he is remaining in college for any other purpose, we have control over him, but he is not bound to remain in the college. And I may venture to say that I was myself personally concerned at the first organisation of these colleges in founding those senior scholarships. Although from the sum total of their emoluments being only 40*l.* a year for one year, it was rather a trifling matter, yet the idea which we had in our minds was that there might be something constituted in connexion with the Queen's University analogous to the class of *agrégés* which exists in Paris, where they have young men who have distinguished themselves, who are not yet appointed professors, but who, by getting a diploma or *brevet* of *agrégé*, are entitled to supplement the professors. In the first place, they deliver a private course of lectures, and they also serve as reserve professors. If a professor gets sick, or if, as often happens in Paris, the professor assumes political or administrative functions, and has to give up lecturing for a time, an *agrégé* is appointed to lecture in his stead. Of course, that puts him on the way of attaining to a higher position if he shows capability. If, by means of assistants in the first instance, we relieved the professor from the amount of drudgery, which at present he is compelled to go through, and if, amongst those assistants, we enabled such as were superior men to show their capability, they would be in such a position that the Government, if it wanted a professor in a certain place, could say : Such a person we have under our hands ; he has already shown what he can do ; in that way it would both give the Government a means of making appointments to professorial chairs in a safer way than is at present done ; and it would also serve to enable the professor to devote himself in part to original investigation, but the existing circumstances almost quite preclude this. I believe that that constitutes almost all that I can say upon that subject.

13,232. (*Chairman.*) Are the professors of the Queen's College appointed by the Government ?—They are appointed by the Crown or by the Government practically. I would in saying that, beg leave to be allowed to add that although I have been now connected with the Cork College from its commencement, and, of course, have had a great number of appointments in that College coming under my notice from time to time, I never yet knew an instance in which the Government in making the selection of a professor ever appeared to have their choice influenced either by personal or political considerations ; in not one case so far as the Cork College is concerned. Of course I can only speak with regard to that. I have known more than one instance where the Government has resisted very strong pressure of their own friends with regard to the appointment of a professor, and have selected a man of whom they knew absolutely nothing, further than that the evidence of competent judges which was submitted to them showed that he was the most desirable candidate. As I have said that the appointments are made by Government, it is only fair to state what my experience of the action of the Government in the case has been, and had my experience been different, I would have stated it just as freely. [See APPENDIX V.]

The witness withdrew.

J. England, Esq., M.A.

JOHN ENGLAND, Esq., M.A., examined.

13,233. (*Chairman.*) You are Professor of Natural Philosophy in Queen's College, Cork ?—Yes.

13,234. Will you proceed to give to the Commission an outline of the courses of instruction in the departments of Mathematical and Physical Science ?—I find that in the President's Report this outline is fully given, but I will just state the more salient points. The Professor of Mathematics has three classes of students ; The course of the first year consists of elementary geometry, algebra, and plane trigonometry. Students, both in arts and engineering, are obliged to attend this course and pass the sessional examination. In the second year the Professor of Mathematics has a more advanced class of engineering students, and there is an option to arts students to take up mathematics or some other subjects in the second year. The second year's course embraces the more advanced parts of algebra, including the theory of equations, spherical trigonometry, differential calculus, and the elements of integral calculus.

13,235. Is this course of lectures generally attended both by arts and engineering students ?—Yes, by such as have previously passed in the first year. The third year is an optional course to students in arts ; it is generally attended by students who are preparing to take their degree with honours in the University, and the subjects taught are geometry of three dimensions and differential equations. The Professor of Mathematics' instructions are confined altogether to pure mathematics ; he does not enter upon the subject of mixed mathematics. At the foundation of the college in 1849 experimental science was not much cultivated ; at least not in Ireland, and consequently the Professor of Natural Philosophy took up the subject of mixed mathematics as a part of natural philosophy, and, in addition to a course of mixed mathematics, he gave a course of experimental physics which was attended by medical students, arts students, and engineering students. On my appointment to the professorship in 1855, I found that this system did not work well. The arts students having previously been in attendance on other courses in the college had a tolerably fair knowledge of mathematics, but, on the other hand, the medical students had been for the most part very deficient in their mathematical education. The difficulty which I had to contend with was that the class naturally divided itself into two portions. If I attempted to give instruction in the higher departments, the medical students could scarcely comprehend it on account of their deficient mathematical education ; and, on the other hand, if I tried to adapt the lectures to them, the arts students were scarcely done justice to. Under those circumstances I found it essential, in order to do justice to

J. England, Esq., M.A.

17 July 1872.

the students, to divide the class into two, thereby, of course, increasing my own work very considerably. Subsequently alterations were made in the curriculum prescribed by the University, and those again I found increased the amount of lectures to be given by the Professor of Natural Philosophy; so that at present, generally speaking, I have about five distinct courses of lectures—first, an elementary course attended by the medical students in experimental physics; secondly, a course attended by arts students of the second year, and engineering students of the second year; thirdly, a course of mathematical physics for engineering students of the third year; fourthly, a special course of applied mechanics; and fifthly, an additional course for students preparing for honours in arts.

13,236. Have you any assistance in the delivery of those courses of lectures?—No assistance whatever, except the aid of a porter.

13,237. What apparatus do you possess for illustrating your lectures?—Sir Robert Kane mentioned that there is every year a certain sum devoted to the purpose, but unfortunately our physical cabinet in Cork is defective for many reasons. Originally there was a sum devoted to the purchase of books and apparatus. There was in Cork a scientific institution called the Royal Cork Institution, and at the opening of the college they lent us their apparatus, and the consequence was that the amount given to purchase new apparatus for the physical cabinet in Cork was very trivial, it being supposed that we could work with the apparatus that was lent to us. This was very old, and was totally inadequate for the illustration of modern science, so that I found it necessary, on my appointment to the office, to have it returned to the institution, and to commence the formation of a physical cabinet of our own. Unfortunately, after we had been a short time collecting apparatus, a portion of the college was destroyed by fire. There was not much actual loss in the physical cabinet, but the funds which would have been otherwise appropriated for the purchase of apparatus in it were devoted to the purchase of materials in the departments that had been destroyed by fire. The apparatus at present in existence is amply sufficient to illustrate an elementary course, in fact to illustrate all the subjects treated of in elementary works, such as Ganôt's Traité de Physique.

13,238. Can you give the Commission any account of the courses of lectures delivered by the Professor of Engineering?—The engineering course extends over three years. In the first year's course the instruction is confined principally to geometrical drawing and to lectures on descriptive geometry and perspective. In the second year the professor lectures on levelling and surveying, and mapping; and in the third year on general engineering and architecture.

13,239. Do you know anything about the students in engineering as to what becomes of them subsequently; have many of them distinguished themselves as engineers?—Yes, a great many have, that is to say considering the number who have attended the college.

13,240. You have heard what Sir Robert Kane has said with respect to the prizes and scholarships; are there any additions which you would wish to make to his evidence upon that point?—No, I think not upon that head. From what Sir Robert Kane mentioned it may appear as if the senior scholarships were practically confined to each college, but, in point of fact, they may be competed for, and are competed for frequently by students from the whole of the three colleges. The condition for competition is that the students should merely have taken their B.A. degree at the Queen's University. It frequently happens that students from Belfast or Galway will compete with the students in Cork.

13,241. There is nothing to prevent the students from the other colleges coming to Cork to compete?—No, there is scarcely a year in which students from other colleges do not come and compete at Cork. A student having spent one year at Belfast or Galway is in a condition to come and compete at Cork for a second year's scholarship.

13,242. (*Professor Stokes.*) And, in a similar way, can students from Cork go to the other colleges and compete for scholarships?—Yes, that increases the amount of competition at each college.

13,243. (*Chairman.*) In point of fact, does it frequently happen that students transfer themselves from one of the Queen's Colleges to another?—Yes.

13,244. (*Professor Smith.*) How far is the education of an engineering student carried at Cork, in order to fit him for the practice of his profession; what other studies must he go through?—Besides the special course of engineering, that is to say, drawing, land surveying, levelling, lectures on the strength of materials, and cognate subjects, he receives lectures from the Professor of Natural Philosophy in mixed mathematics, and the application of mechanics to engineering purposes. He further attends lectures in mathematics, embracing geometry, algebra, trigonometry, and calculus, and whilst attending the lectures of the Professor of Engineering he has an opportunity of learning the use of mathematical instruments, and I believe it is essential that he must have made a map of some district surveyed by himself and mapped by himself.

13,245. Are there any opportunities in Cork for his having instruction of a more practical kind; are there any works of any kind available for the purpose?—To a limited extent. There are generally works going on connected with the local railways, or with the improvements of the river.

13,246. When a student has completed his course, you hardly consider him competent to enter his profession?—No, they generally go to an engineering office for a time, and they compete for the Indian appointments which are at present open to them.

13,247. Have any of those students been successful in obtaining appointments in the Indian engineering service?—Yes; I cannot exactly give the number, but it is in the President's Report. I know, as a matter of fact, that a very considerable number of students who have competed for the Indian Service, have been successful. For instance, last year in the Indian Civil Service examination, Mr. Blyth obtained a place, Mr. James Magill obtained an army medical appointment by competition, and three gentlemen obtained appointments in the Indian Medical Service by competition, and Mr. Hill, who is one of our engineering students, obtained the silver medal and life studentship given by the Royal Academy of London for the best drawing, from actual measurements from any existing building. Mr. Hill, I may observe, has left the college for some years.

13,248. (*Chairman.*) Are there any additions which you would like to make to your evidence?—No.

13,249. Do you think that you have stated the principal points?—Yes.

The witness withdrew.

JOHN PURSER, Esq., M.A., examined.

J. Purser, Esq., M.A.

13,250. (*Chairman.*) You are Professor of Mathematics in the Queen's University in Ireland, and in Queen's College, Belfast?—I am.

13,251. I presume that the connexion of Queen's College, Belfast, with the Queen's University is precisely on the same footing as the connexion of the other Queen's Colleges?—Precisely.

13,252. Is the staff of professors the same?—With one exception it is. In Belfast the Chairs of Geology and Natural History have been amalgamated, which has not been done in the other colleges.

13,253. As far as your own faculty is concerned, is it on the same footing?—It is precisely the same.

13,254. The students are divided, are they not, into four faculties?—Yes.

13,255. Is the curriculum, in each faculty, the same

J. Purser, Esq., M.A.

17 July 1872.

as at Cork and Galway ?—I think almost precisely the same.

13,256. As Professor of Mathematics, do you find that you have any special difficulties to contend with ?—My principal difficulty arises from the widely different degrees of progress students have made before they enter college. We grant, in Queen's College, Belfast, scholarships to students at entrance, and half of them are given for attainments in pure mathematics. These are very eagerly competed for, and consequently we find a contingent of the students come up well prepared. On the other hand, the greater number of the students in arts know but the first elements of mathematics, consequently it becomes exceedingly difficult for the professor to teach all at the same time. I and my predecessors have endeavoured to meet this difficulty to a certain extent by making use of the senior mathematical scholar, a graduate, who has been elected to a scholarship for one year after taking his degree. I have derived in this way much valuable aid from the senior scholars, but such aid is quite insufficient, and a regular and permanent assistant to my chair is most urgently needed to render the training in the mathematical school thoroughly efficient.

13,257. Are you authorised to call upon the senior scholars for assistance ?—Yes, we are ; but in many cases the senior scholars are studying for a profession or some civil service appointment, and it becomes very irksome to them to have their time drawn upon to any large extent, and the college feel a difficulty in doing so.

13,258. With that exception, you have no other assistance ?—We have no other assistance.

13,259. Can you describe generally the extent of your duties, that is to say, the different courses of lectures that you are called upon to deliver ?—I have three courses. The first, to students of the first year, attended by all the students in arts and engineering. These students, owing to the circumstances already explained, I have to divide into two divisions, according to their proficiency, and to divide my time between them, supplementing my instruction to the lower division by that of the senior scholar. My next course is to students of the second year, attended by all the engineering and a few of the arts students. My third course is an advanced course in higher mathematics.

13,260. In the first and second years you have to adapt your courses of lectures to classes in very different states of preparation ?—Yes.

13,261. Have any of the students the means of getting assistance in addition to the instruction which they receive from you, as professor ?—Some of our graduates and scholars take private pupils. Our students generally are not able to pay for much private teaching, and consequently the system has never attained dimensions of any importance.

13,262. In the third year your lectures are confined, are they not, to those who are candidates for honours ?—It is a course in the higher mathematics arranged for those who are candidates for honours.

13,263. Of what length are the courses in arts and medicine ?—The course in arts extends over three sessions, and that in medicine over four sessions.

13,264. In engineering, does the course extend over more than three sessions ?—No, only over three sessions ; in fact, in the engineering school there is a provision, which is very seldom made use of, that students can take the course in two sessions if they have acquired, before coming to college, a satisfactory knowledge of the earlier part of the curriculum ; but the regular course in engineering extends over three sessions.

123,265. Have you a distinct course of lectures intended for engineers in any year ?—No, there are no separate lectures in mathematics to engineering students. The institution of such separate lectures, especially in the second year, would be one of the first changes I should make, had I an assistant.

13,266. Can you give the Commission some information with respect to the instruction given in the school of engineering, in addition to your own lectures ?—The curriculum in the school of engineering consists, in the first year, of a course in mathematics, in experimental physics, in chemistry, in modern languages, in geometrical drawing, and office work, the last two with the professional engineer. In the second session, the course is mathematics, second course mathematical physics, mineralogy, geology, physical geography, civil engineering, office work, and field work. And in the third session, natural philosophy applied, civil and mechanical engineering, office work, field work, and engineering excursions. The Professor of Engineering, Professor James Thomson, considers that the course in engineering is well adapted to be useful to others than those who are intending to take up engineering as a profession. He has sent me a paper containing his views, which, with your Grace's permission, I will lay before the Commission.

QUEEN'S COLLEGE, BELFAST.

ENGINEERING DEPARTMENT.

Professor James Thomson, LL.D., Professor of Civil Engineering in Queen's College, Belfast, submits the following remarks on the nature, the scope, and the uses of the courses of teaching and study which are provided in the Engineering Department in the Colleges of the Queen's University in Ireland. In respect to details, his remarks relate more especially to the arrangements and usages in Queen's College, Belfast.

" The engineering course, as a whole, has been mainly arranged with a view to making it suitable for students intending to enter on the profession of civil engineering. The same preparatory studies and training, however, which are desirable for civil engineering are also highly useful for many other walks of life. For the civil engineer, the scientific studies primarily essential comprise mathematics, natural philosophy, and chemistry ; but while these are all of high value to him, they are also valuable to the mechanical engineer, the military engineer, the telegraph engineer, the architect, the ship builder, the flax spinner, the linen bleacher, and to the sugar producer and manufacturer, and the list might readily be extended almost indefinitely. Among the subjects, not specially engineering, which are comprised in the course, there are geology and modern languages, subjects which conduce to a good liberal education in any path in life whatever. All the subjects as yet named are studied by the engineering students in common with the students in other departments of the College. Next, as regards the courses taught by the Professor of Civil Engineering, it will be found that even in them there is but little labour imposed on the diligent student which is not of a kind adapted to extend his qualifications, both in knowledge and in skill, for many kinds of practical business besides civil engineering. These subjects may be thus sketched out :— 1. Geometrical drawing, including the general principles of the accurate representation on flat surfaces of the forms and dimensions of solid objects, and including the art of perspective, together with practical drawing, especially in relation to engineering and architectural subjects. 2. Surveying, levelling, and mensuration, including various operations of measuring over the surface of land ; and mapping, drawing, and calculating within doors in connexion with such measurements. 3. A variety of lessons, adapted to afford an introduction to many of the chief subjects of study which are liable to be wanted by the civil or mechanical engineer, and by the architect, and by many other classes of artificers and practical men. Of these it may suffice to mention :—Hydraulics ; strength and elasticity of materials ; bridges of various kinds ; ornamental architecture ; and subjects more particularly relating to mechanical engineering. Now out of the whole special teaching for engineering students, there is little, if anything, required to be studied, or laboured at, which may not be attended to with advantage by many besides those who may eventually select civil engineering as a profession. An acquaintance with such subjects as perspective and as ornamental architecture, ancient and mediæval, while important to the architect and the engineer, cannot fail to be both useful and interesting to any whose tastes lead them at all towards the cultivation of the fine arts. The Greek and Latin languages are not included in the course required of engineering students. This is from no want of appreciation of the value of such studies ; but it is simply on the old principle that no man can attempt to grapple with all branches of knowledge, and that some which might be very desirable must be omitted for want of time —' *Non omnia possumus omnes*' —we cannot all do all things. Literary studies, however, are not entirely omitted from the requirements of the University in the case of engineering students, as one modern foreign language, at least, is made essential. It will be perceived, then, that the engineering course has much in common with the courses of students in other departments in this College. It differs from the course of many of the arts students mainly in the omission of Greek and Latin, and in the introduction of courses of professional teaching, but only a small part of it can be looked on as being specially technical. It may thus be observed that the courses of instruction provided in the Engineering Department in the Queen's Colleges are eminently suited, as preparation, not only for the various branches of the profession of civil engineering, but also for numerous other paths in life, more or less directly connected with the constructive arts.

"The courses of lectures and practical instruction given by the Professor of Civil Engineering are arranged to accord with the ordinances of the Queen's University, which prescribe to candidates for the diploma in civil engineering a curriculum extending over three sessions usually, but admitting of abbreviation to two sessions in the case of students whose previous acquaintance with a sufficient group of the subjects prescribed for study in the first and second sessions of the ordinary course shall be deemed by the College Council satisfactory.

"For the first year's students, the professor gives a course of instruction, comprising lectures and oral examinations, on the principles of geometrical drawing, and the performance by the students of practical work under his direction. The lectures include the principles of descriptive geometry, orthographic and isometric projection, and linear perspective; and the practical work comprises the performance of examples in these subjects, and the execution of drawings in mechanical engineering, and, occasionally, also, in architecture and civil engineering. The class meets for two hours at a time on two days per week during the three terms of the College session.

"For the second year's students, two courses are conducted by the Professor of Engineering, of which one is a lecture course and the other a practice course. The lecture course comprises surveying, levelling, and plotting, with the theory and use of the instruments required in surveying and levelling operations; mensuration of earthworks for railways; setting out works on the ground, including ranging of railway curves, and setting out breadths of cuttings and embankments, and ranging tunnels, &c. The course also comprises, usually, some of the following subjects:—Revision and farther prosecution of descriptive geometry, and perspective, and other subjects of geometrical drawing; designing and drawing of oblique bridges; properties and qualities of materials used in construction, and modes of procuring them; and an introduction to architecture as a fine art.

"In the practice course of the second year, the students are engaged in the performance of office and field work, under the instruction and direction of the professor; and the business includes surveying, levelling, drawing, mapping, and the computation of areas of lands, and other engineering calculations. Excursions are also made occasionally, during the session, to visit engineering works.

For the third year's students, there are (as for those of the second year) two courses conducted by the professor, one a lecture course, and the other a practice course. The lecture course comprises the farther treatment of some of the subjects proposed to be entered on in the second year, and most of the following subjects:—Foundations, cofferdams, bridges, tunnels, roads, and railways; specifications for engineering contracts; waterworks for supplying towns; science of the flow of water in orifices, pipes, and canals; drainage of fens by gravitation, and by steam power and other mechanical means; science of the strength of materials and structures; ventilation of dwelling-houses, public buildings, and mines; processes and mechanisms used in foundries and engineering workshops.

"The practice course includes office work, field work, and engineering excursions.

"In Queen's College, Belfast, a system has been introduced, and has been found to work well, of keeping the drawing class room open during the whole day for all students of engineering in attendance at college who choose to ask for admittance, and who give promise of good conduct if admitted at extra hours, when the professor is not present. This system has been practised for the last eight years, and has been acted on by every student without exception; and the promise given by the students to be careful to conduct themselves well has been very generally and very faithfully kept; no serious case of disorder having ever occurred, and much good practical work having been done."

J. Purser, Esq., M.A.

7 July 1872.

13,267. In point of fact, do any of the students attend the engineering course who do not intend to become engineers?—I do not think that many do. I believe those entering the engineering school almost invariably intend, at the time, to make engineering their profession, but, from different circumstances, some attend only part of the course, and then take up other studies.

13,268. Do some attend for the first year, or the first two years, and then discontinue?—Some do. The examinations sometimes stop their progress, or perhaps their pecuniary means do not allow of their remaining at college.

13,269. The course of instruction that the engineering students receive is not supposed, is it, to enable them to dispense with subsequent work in an engineer's office in learning the practical part of their profession?—No, certainly not; the Professor of Engineering regards such subsequent training in an engineer's office, or in practical work with a contractor, as quite essential.

13,270. Could you give the Commission any information with regard to the instruction given by the Professor of Chemistry?—The Professor of Chemistry, in addition to his chemical lectures, has a large number of laboratory pupils. He generally admits from 8 to 12 students every year, free of charge, to work in the laboratory, and he has found the arrangement to work remarkably well.

13,271. Are they not strictly speaking students of the University?—They are generally students of the University, but out of the students of the University there are selected, by examination, some 8 or 12 to practice in the laboratory, and the Professor makes it a kind of reward. He would confer the same privilege on any who passed the examination, who had attended his lectures, although not belonging to the University, but practically they are almost invariably students of the University, and the privilege is highly prized by the students.

13,272. Are engineering students obliged to attend one or more courses of the Professor of Chemistry?—Yes, the engineering students are obliged to attend this course once, and they very often do attend of their own accord a second time.

13,273. And medical students also? -Yes; except such as may have taken out a class in chemistry at another medical school.

13,274. Must all the arts students attend?—The course in chemistry is one of the regular courses to be attended in the third year by arts students, but only some attend, as a very large latitude of choice is allowed to students in the third year.

13,275. Is the same number of scholarships awarded at the Belfast College as at the other colleges?—Exactly the same, so far as the scholarships given by the Government are concerned, but we have one or two scholarships given by private endowments; there are three scholarships founded by the late Dr. Sullivan, of 40*l.* a year, tenable for three years, and two, founded by the late Mr. Porter, of 50*l.*, tenable for two years.

13,276. Are any of those private endowments restricted to any particular branches of instruction?—They are not restricted to any special branches. The holders of the Sullivan scholarship must pass the college examinations prescribed for the first and second year's undergraduate course in arts, but in the third year they may devote their attention to professional objects, such as law, medicine, or engineering.

13,277. Is there a special examination for those scholarships?—Yes, there is a special examination for them.

13,278. Does the examination range over a wide number of subjects? The examination, in the case of the Porter scholarships, is a very extensive one, ranging over Greek, Latin, mathematics, natural history, modern languages, and logic, separate marks being assigned to each.

13,279. Is an acquaintance with all those branches of knowledge required?—No, it is on the same principle as the Indian Civil Service Examination; the

J. Purser, Esq., M.A.

17 July 1872.

student that attains the highest score gets the scholarship, even although he has not answered at all in some one or more of the subjects.

13,280. What funds are at the disposal of the College for the maintenance of the scientific and medical museums and laboratories?—The whole fund that we have for the maintenance of the College consists of 1,000*l.* a year, which is supplemented by about 100*l.* a year, arising from a small college or matriculation fee of 5*s.* Out of this 1,100*l.* a year, in the first place, we have to pay for the office expenses, stationery, and advertising, for keeping the grounds in order, and for heating and lighting the premises in the College. These charges consume about 550*l.*, leaving 550*l.* Of this about 300*l.* a year is spent in purchasing books for the library, and is found very insufficient for the purpose. There remains about 250*l.* for maintaining the natural history museum, all the medical collections, the chemical laboratory, the natural philosophy apparatus, and the engineering instruments, and it has been found, constantly, now for a great many years, quite inadequate to meet the wants of the college. Previously, about 10 years ago, the vote was 1,600*l.* a year instead of 1,000*l.*, but the 600*l.* was withdrawn by the Treasury when the salaries of the professors were augmented, and it is now found that 1,000*l.* is quite inadequate.

13,281. Do you feel the want of larger funds of that kind very sensibly?—Very sensibly; our library greatly needs a more liberal supply. We require so much for technical books, that for books of a general interest we have very insufficient means. As one consequence of the want of funds we have no physical laboratory, a need which is greatly felt, but, as it is, we have no means for maintaining such. The chemical laboratory has been very successful, but we cannot institute a physical laboratory without more funds. The Professor of Natural Philosophy is anxious to establish one, and to have a trained assistant to help him with his classes, and to enable him to give more of his own time to physical investigation.

13,282. Is there sufficient space in the building to establish such a laboratory if you had the funds?—I believe so; we have rooms which could be devoted to that purpose, sufficient for the present, till the requirements become larger.

13,283. The Colleges have no endowment from private sources, except in the shape of the scholarships to which you have already referred?—No; except those scholarships I know of no endowment.

13,284. Are most of your students natives of Belfast?—No; I can hardly tell what proportion comes from Belfast, but it is a small proportion. A large proportion, indeed, are educated in Belfast after having come up from the country, but it is only a small proportion that are natives of Belfast itself.

13,285. Are there any other educational establishments in Belfast where the education is at all of the same character as in Queen's College? None whatever; we have in Belfast an old institution called the Royal Academical Institution, in which, in former times, there were some collegiate chairs, but those who held those chairs were transferred in some instances to Queen's College. The late Dr. Stevelly, and our vice-president, Dr. Andrews, held chairs in connexion with the Belfast Academical Institution. That institution is now the high school, and our best feeder.

13,286 (*Professor Smith.*) Dr. Andrews is your Professor of Chemistry, is he not?—Yes.

13,287. Is he sufficiently supplied with assistants for the purpose of his lectures and the work in the laboratory?—He has no assistant paid by the College at all; he pays an assistant himself. He is the only professor who has an assistant, except the Professor of Anatomy. His assistant is also paid out of his own pocket.

13,288. I suppose Professor Everett has some physical laboratory for the purpose of preparing his lectures? He has the room containing the apparatus for his lectures, but we could hardly call it a laboratory.

13,289. Is there any place in which the professor himself can carry on original investigations of his own; has he any opportunities of that kind?—No, there is no room properly furnished for the purpose.

13,290. Is the library considerable in extent?—I am not prepared to say the number of volumes in the library. The colleges were opened, I believe, in 1849, and we have been purchasing books, at first at the rate of 600*l.* a year, and for the last 10 or 12 years at the rate of 300*l.* a year, and that will give an idea of the size of the library. We have also received from private individuals some valuable presents.

13,291. Was there no original grant for the library when the college was founded?—I do not know. I am not familiar with the circumstances connected with the foundation of the College.

13,292. (*Chairman.*) Sir Robert Kane told us that there was 4,000*l.* originally given to Cork, and probably it would be the same at all the colleges?—I find it was so, but that this sum was for the establishment of the museums and collections as well as for the library.

13,293. (*Professor Smith.*) Are the repairs of the college at Belfast chargeable upon this fund of 1,000*l.* a year?—No, they are borne by the Board of Works.

13,294. (*Chairman.*) Are you able to give the Commission any information as to the fees charged?—The fees charged are all given in the College Calendar, which I hand in.

13,295. Do they all go to the professors, and does no part of them go towards the college expenses?—There is a small 5*s.* fee, which goes to the college, but with that exception the fees all go to the professors.

13,296. Are all the fees the same in amount?—Nearly all the fees are 2*l.* fees for the session. There are some courses which extend only over one term, in which the fees are 1*l.*; and in some of the medical classes the fees are higher.

13,297. What are the emoluments of the professors derived from the fees in those schools?—The President's Report contains the emoluments of the professors derived from the fees.

13,298. In 1869 it appears by the return that the fees of the Professor of Greek amounted to 109*l.*, some years they reached 230*l.*, and about 10 years ago most of them seem to have been rather higher; were there at that time a larger number of students?—In the faculty of arts there was a considerably larger number of students about 10 years ago. The medical school, I believe, is considerably larger than it was at that period.

13,299. The fees of the Professor of Logic appear in 1869 to have been 117*l.*, mathematics, 148*l.*, natural philosophy, 177*l.*, but those do not seem to have fallen off very materially?—The fees of the Natural Philosophy Professor depend upon the number of the medical students, as well as upon that of the arts students.

13,300. The Professor of Chemistry had 250*l.* in that year, and one year it had been 299*l.*, and the Anatomy and Physiology Professor appears to have received by far the largest amount of fees, last year it being 592*l.*, and the year before 731*l.*, and in one year the natural history and botany was about 100*l.*, and it has been as high as 170*l.*; modern languages were 255*l.* 5*s.* last year, and mineralogy and geology 16*l.*?—The course of mineralogy is specially intended for engineering students.

13,301. All the rest of the income from fees of the medical chairs and of the law chairs, as a rule, are smaller, with the exception of surgery about 120*l.*, none of the rest come up to 100*l.*?—No.

13,302. Can you assign any reason for that falling off in the number of arts students in the last 10 years?—We have found it very difficult to ascertain the cause. It is partly, I believe, connected with the fact that the number of candidates for the Presbyterian ministry has of late years diminished, such candidates usually taking the arts course before entering the Presbyterian Theological College. It has also been sometimes said, and I believe there is

J. Purser, Esq., M.A.

17 July 1872.

a great deal of force in it, that when trade is exceedingly prosperous, the fathers prefer to send their sons to trade and business rather than to a profession, and that the falling off has arisen greatly from this cause.

13,303. Then their prosperity does not make them value education more?—No; I wish it did.

13,304. (*Professor Smith.*) I noticed that there is a fee of 3*l.* for practical chemistry. I presume that is for the laboratory courses?—This is the fee for medical students who have to attend a summer course in practical chemistry. These are distinct from the students I alluded to before, who are admitted by examination to work in the laboratory, and who get a more extensive course of training.

13,305. And that is gratuitous?—Yes. These last are admitted gratuitously. A certain number are appointed every year, who are elected by examination.

13,306. So that Dr. Andrews not only provides assistants out of his own pocket, but also provides gratuitous instruction to the laboratory students?—Yes.

13,307. (*Sir J. P. Kay-Shuttleworth.*) Do you think that the apparatus in the laboratory of the Professor of Chemistry for the purposes of practical instruction is sufficient?—I believe the chemical apparatus, if fully maintained, is sufficient, but to do so with our present funds is hardly possible.

13,308. With regard to natural philosophy, you consider it decidedly inadequate?—Decidedly inadequate.

13,309. (*Chairman.*) Do you know what the annual vote of Parliament to the College for all purposes amounts to?—The annual vote for all purposes amounts to 1,374*l.*, namely, 1,000*l.* for the maintenance of the College generally, and 374*l.* for the augmentation of the salaries of the professors. 374*l.* instead of 600*l.* is all we receive for the latter purpose, as a saving was effected by the Government by the amalgamation of the natural history and geological chairs. We have 7,000*l.* a year out of the consolidated fund to pay the officers' and professors' salaries, and for scholarships and prizes.

13,310. Is 8,000*l.* a year the total amount which the college receives from the State in any shape?—8,374*l.* is the exact amount.

13,311. (*Professor Huxley.*) By whose authority was the balance of 600*l.* diverted from its original purpose to increase the salaries of the professors?—By the authority of Government.

13,312. Was it on the representation of the professors?—The professors very strongly represented to the Government the inadequacy of their salaries. The transaction occurred about 10 years ago, before I was connected with the College, and whether it was the Government or any of the individual professors that first suggested this particular way of meeting the difficulty, I cannot say. As a body, the professors I believe, were no parties to it, and most of those who have spoken to me on the subject regret exceedingly that the needful augmentation was not made without trenching on the funds of the College for the supply of apparatus and books.

13,313. (*Chairman.*) Is there any other point upon which you wish to give evidence?—Nothing, except to say that I think our most pressing want is that the annual vote for College expenses should be raised from 1,000*l.* to what it originally stood, at 1,600*l.*

13,314. Do you think that that would be about adequate to meet the wants of the college?—I think that an addition of 600*l.* a year would be about adequate to meet our wants.

13,315. Could you give us any information as to the success of your students in subsequent life?—Perhaps I may be allowed to hand in a statement on that subject, which has been sent to me by the order of the President. It is as follows:—

It appears from notes in the University Calendar that Belfast College has educated, among many other successful men, the following persons:—

20 members of the Civil Service of India.
10 members of the Consular Service.
5 engineers of public works in India.
2 members of the Geological Survey of India.
33 members of the Army Medical Service.
14 „ Navy „
2 secretaries, Chinese Embassy.
1 Inspector-General of Customs in China.
3 officers of engineers.
12 professors of colleges and universities.
4 assistants to professors.
5 head masters of collegiate and academical institutions.
6 inspectors of national schools.
3 Harrington lecturers.
2 members of the Senate, Queen's University.
5 law students, Inns of Court.

[See Appendix V.]

The witness withdrew.

R. O. Cunningham, Esq., M.D.

Robert O. Cunningham, Esq., M.D., examined.

13,316. (*Chairman.*) You are, I believe, Professor of Natural History in Queen's College, Belfast?—I am.

13,317. Will you have the goodness to describe to the Commission the duties that are attached to your professorship?—I have, I may say, in the first place, three courses to conduct, one of zoology, one of botany, and one of geology, and in addition to that I am curator of the Natural History Museum.

13,318. In the other colleges are the duties of the Natural History Professor as extensive as those in your college?—No, they are not. In Cork and in Galway the Professor of Natural History teaches botany and zoology, and there is a separate professor of geology.

13,319. What has occasioned a different arrangement at Belfast?—It took place so long before I came there that I am afraid I cannot state the matter very accurately, but I believe that the Government consented to the augmentation of the salary of the Professor of Natural History on condition that he should take up additional duties when the other Chair became vacant in his particular college, and I believe that when the Professor of Geology in Cork and Galway retires or dies, the Professor of Natural History must take up the other course; in the same way I believe the Professor of Geology must take up zoology and botany, but I cannot say how that was brought about.

13,320. (*Sir J. P. Kay-Shuttleworth.*) Have you any objections to state to the Commission the present amount of the emoluments of the professors?—They vary from year to year. I could tell you with regard to last year. My Government salary, taken in connexion with my examinership in the Queen's University, comes to exactly 300*l.* a year, and my fees last year, including three courses, came to, I think, as nearly as possible, 150*l.*

13,321. Can you state what they had been before the consolidation?—I cannot, because I have only been in connexion with the college for the last 18 months.

13,322. But they must have been something like the half of that, I suppose, for the separate professorships?—No, by no means, because the Professor of Geology makes so very little by his fees that it makes very little difference; the classes of geology are so small; the bulk of the fees are derived from the zoology and botany, which all medical students must attend, and third year's arts students attend.

13,323. But it was an addition of the salary of the Professor of Geology to the salary of the Professor of Natural History and Zoology?—I believe that was the state of the case, but I cannot speak very particularly, because it was done so long before I came to the college.

13,324. (*Chairman.*) Are the students who attend your courses of botany and zoology chiefly medical students?—I should say that two thirds of them were.

13,325. But in the case of arts students, are botany

R. O. Cunningham, Esq., M.D.

17 July 1872.

and zoology of use to them in taking their degrees?—Yes, the third year's arts students either take zoology or botany as one of their subjects as a rule. Perhaps I should mention that there is only one fee for zoology and botany.

13,326. Are the engineering students all obliged to attend your lectures on geology?—Yes, they are all obliged to do so.

13,327. Do any other students besides those attend?—Very few comparatively speaking, because it does not count with either medical students or arts students as a class, except in the third year's honours course.

13,328. It is of no use to them in obtaining degrees?—Of no use at all.

13,329. Are you provided with a museum?—Yes, we have a museum.

13,330. In all those separate branches of your professorship?—Yes. The geology and the zoology are best represented upon the whole, but we have a very fair herbarium of British plants, and there is the Botanical Garden belonging to the town, which allows us specimens of plants during my course on payment of a certain sum by the college to the garden.

13,331. Are you provided with any assistants in the delivery of your lectures or in preparation for them?—No, none.

13,332. A certain amount of the grant of 1,000*l.* a year, of which we have heard, is, I presume, applied to your apparatus?—Yes, I get altogether, I should think, between 50*l.* and 60*l.*

13,333. Is the library pretty well supplied with works on Natural History?—So far as regards works that are suitable for students it is, but as regards more abstruse works it is very insufficiently provided indeed.

13,334. Under whose control are the additions that are annually made to the library? have you a voice in the distribution of the money which is applied to that purpose?—Yes, I have a voice as regards the books in my own department.

13,335. (*Professor Huxley.*) Do not you find your work very hard?—I do find it very heavy.

13,336. How many lectures do you have to give in the course of the year?—About 60 in zoology, 50 in botany, and 40 in geology.

13,337. I presume that we need hardly ask you whether you think the arrangement now existing an advantageous one?—I think that is decidedly disadvantageous.

13,338. You find it quite impossible, do you not, to give any practical instruction?—I give it to a certain extent, so far as the students have time for it. I generally make the botanical course as practical as I can, because in addition to lecturing five days in the week, I take excursions on Saturdays. Of course, both as regards zoology and botany, I illustrate my lectures with as many specimens and diagrams as I have in my power, but still there are many things that it would be impossible for me to attempt, both on account of the want of time and the want of apparatus, and also on account of most of my students being medical students, who merely take up zoology for one year along with a number of other subjects.

13,339. Have you dissecting rooms belonging to the college?—No; we have nothing of the sort. I can do nothing in that way.

13,340. Have you no lecture-room assistants or demonstrators?—No, nothing of that sort. I have a senior scholar who is appointed annually in my department, and he is supposed to give me some help when I call upon him to do so in connexion with other duties. If he is a very good man I may occasionally get a little help from him in the museum, but nothing very essential.

13,341. Are you also expected to keep the collection in the museum in order?—I am.

13,342. Have you any assistant there?—There is no assistant there at all. Of course there is a servant attached to the college, but he does not belong to me alone, so that I can only get a piece of him; he does happen to be a very good man, and I find him very useful in some respects, but he is merely a man in the position of a college porter.

13,343. Is there anyone who can undertake the preparation of a skeleton or making preparations?—There is nobody in *my* department, but there is a porter who is attached to the Professor of Anatomy, and is a very good man, though just in the same position as a college porter; he is a man of a great deal of talent, so that if I wanted a skeleton prepared it could be done by him, but I cannot claim his services. All our skeletons are bought from London just now.

13,344. With respect to Geology, do you take your students out upon excursions in the neighbourhood?—As yet I have done nothing in that respect, because, as it happened, last year was my first winter, and of course I had both zoology and geology to conduct, so that I found that it was utterly impossible to do so, but it will be my object on Saturdays, at all events, three or four times in the course of the session, to do so.

13,345. I presume that you would be very glad to return to the previous state of things when there was a distinct Professor of Natural History from the Professor of Geology?—Yes, zoology and botany could be very easily managed, because zoology is taught in the winter and botany in the summer, but it is very heavy work conducting a course of zoology and a course of geology together.

13,346. Supposing that you could have your own way altogether, with a view to the interest of the professors as well as the students, do not you think that it would be better if zoology and botany were separate?—Yes.

13,347. I presume that this great drain upon your energies could not possibly leave you much time for original work or inquiry of any sort?—There does not seem very much prospect of it, because by the end of the course I confess that my energies are so much exhausted that I do not feel fit for much more.

13,348. You were naturalist to the Nassau Expedition, were you not?—Yes.

13,349. In what year did she sail from England?—In 1866.

13,350. During the course of your voyage you visited a place in Patagonia for the purpose of collecting fossils, did you not?—Yes, Rio de Gallegos.

13,351. The visit to that place was not contained in the original instructions of your captain, was it, when he sailed?—Yes, I believe it was by the time he sailed, in consequence of a memorial that was presented.

13,352. Are you aware how it was that you came to visit that place?—I believe it was in consequence of a memorial signed by Mr. Darwin and yourself, and the Hydrographer, I believe, was personally interested in the matter, because he made the discovery of the deposit there in company with Admiral Sullivan, who also wrote a letter urging that the deposit should be visited.

13,353. You obtained, did you not, some important fossils there which were sent home?—Yes.

13,354. To whom were they sent by you?—They were sent to yourself.

13,355. But not as the result of the expression of any wish of mine, I believe?—No, I do not think there was any wish expressed by any person. I sent them to the person who I thought took the most interest in them, for although, of course, the Admiralty could send them where they chose, they very obligingly sent them wherever I advised them to be sent.

13,356. It was the understanding, was it not, that everything was sent home officially to the Admiralty, but your wishes in the matter were attended to?—They were invariably. I merely sent in a note each time that I despatched specimens, and they were always forwarded to the destination that I suggested.

13,357. (*Chairman.*) Is there anything further which you would wish to state with respect to the Belfast College?—I would merely say that the sum that we have for museum purposes and apparatus is wholly insufficient. I have only about 50*l.* for specimens, diagrams, and everything else connected with my department.

R. O. Cunningham, Esq., M.D.

17 July 1872.

13,358. What sum would, in your opinion, be sufficient for that purpose?—I think I could get on pretty comfortably with 100*l.*

13,359. For all three departments?—Yes, I could make that do.

13,360. (*Professor Huxley.*) But you would like to have an assistant as well?—Yes, I should certainly like to have an assistant as well, but as regards diagrams and specimens to illustrate my course, probably the sum mentioned would be sufficient.

The witness withdrew.

Adjourned to to-morrow at 12 o'clock.

No. 6, Old Palace Yard, Westminster, Thursday, 18th July 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., F.R.S.

ROBERT DYER LYONS, Esq., M.B. T.C.D., &c., examined.

R. D. Lyons, Esq., M.B. T.C.D.

18 July 1872.

13,361. (*Chairman.*) Will you have the goodness to state to the Commission the office which you hold in the Catholic University of Ireland?—I am Professor of Physiology in the Faculty of Science, and Professor of Medicine and Pathology in the Faculty of Medicine, and I also fill at present, and for the fifth time, the office of Dean of the Faculty of Medicine.

13,362. Are the Commission to understand that the University is strictly a Catholic institution, and is entirely under the management of Catholics?—It is entirely under the management of Catholics.

13,363. And solely for Catholic students?—Not solely for Catholic students, because as a matter of fact we have admitted others, and still admit them.

13,364. But all the professors and officers of the University are necessarily Catholics, are they not?—They are as a matter of fact, but I would not say that they necessarily are so, because I believe that it was at one time within the view of Dr. Newman that others than Catholics might hold professorships.

13,365. In what year was the University founded?—The University was founded in the year 1850.

13,366. Will you be so good as to state to the Commission generally the objects for which the University was established?—It was established for the purpose of supplying superior education to the great body of the Catholics of Ireland, who had no University open to them which, in the view of their parents and guides, they could avail themselves of; and it was also opened in order to provide means and appliances for Catholic men of ability to pursue the various departments of science in Ireland, from which, up to that period, it may be said they were practically excluded. I may say that I am myself a graduate of the University of Dublin, and long resided within its walls, and at the time that I was in the University there was no post of emolument, nor even any prize of substantial value, open to any Catholic—no professorship, no fellowship, no scholarship, no one position, in fact, of emolument or importance was then open to a Catholic.

13,367. What are the branches of instruction for which provision is made in the Catholic University?—It was established on the basis of a complete *Universitas*, including several schools or faculties, purporting, in fact, to include all the schools and faculties which are usually recognized in all the Universities of older standing.

13,368. How is the University governed?—The University is governed, subject to the control of the Episcopal Board, by the Rector with the Rectorial Council, and by the University Senate, laymen being largely in excess in both bodies. The council is composed of the deans of faculties, and of certain representatives elected by the faculties, the senate, and the heads of houses. The Senate is an assembly of the entire University corps.

13,369. Is the University provided with any endowment?—The University is provided with a certain amount of funds, which are the result of a public collection made partly in Ireland, partly in England, and partly throughout the United States of America, and it may be said throughout the Catholic world generally; and if the Commissioners will permit me, I will hand in as part of my evidence a return published in the year 1855 of the then condition of the corpus of that fund. It amounted in all at that time to 58,070*l.* 1*s.* 5*d.*, 27,616*l.* of which had been collected in Ireland, 16,000*l.* in the United States, 4,166*l.* in England and Scotland, and the balance in various places. That may be treated as the corpus of the fund on which the University is based, and a large part of that sum was invested in the purchase of buildings and the initiation of museum collections, and certain annual allocations were devoted to the several faculties, including the faculty of science. Since that account was published more money has been collected, and I believe I am entirely within the facts when I state that fully 150,000*l.* have been collected by voluntary contributions, mainly in Ireland, and applied to the purposes of the University.

13,370. (*Sir J. P. Kay-Shuttleworth.*) Can you define what proportion of the 150,000*l.* has been applied to the corpus, and what has been applied to the annual expenditure of the University?—I could not exactly do that, because the whole fund has been more or less deteriorated by other things than the annual expenditure; and there are one or two points which, in a further stage of my evidence, I would like to refer to as bearing upon this question.

13,371. (*Chairman.*) Have additional funds been raised for the purposes of prizes and scholarships?—Yes, extensive funds have been raised by contributions throughout several of the various dioceses of Ireland, and I shall be able to hand in a copy of a document which contains a list of all the prizes and scholarships now open for competition in the University, and although these are practically confined to Catholics, still we do not exclusively regard them as such. And I may mention that more than one student professing the Protestant creed has enjoyed a scholarship of some considerable emolument in the University. This sheet contains a list of the exhibitions and prizes to be competed for in the year 1872 (*delivering in the same*). [See APPENDIX VI.]

13,372. Can you state the total amount of exhibitions and scholarships annually given?—The amount for the present year is in all about 700*l.*, exclusive of gold medals. The allocations of the various sums will be best understood by an inspection of the annexed sheet, which I beg leave to hand in for insertion in your Appendix. It exhibits the working of the entire University. [See APPENDIX VI.]

13,373. (*Professor Huxley.*) You stated, I think, just now that the particular religious profession of any

R. D. Lyons, Esq., M.B. T.C.D.

18 July 1872.

student would not be a bar to his obtaining any exhibition for which he might be qualified; does that apply to all the faculties?—It does, except of course to the faculty of theology.

13,374. But excluding the faculty of theology, it applies to all?—Yes.

13,375. (*Chairman.*) Would you be so good as to go on to state how the corpus of the fund has been applied?—The corpus of the fund has been applied in various ways; a part of it still remains in stock, but a considerable part of it has been expended in the purchase of a site and buildings, and of objects for museums, a physical cabinet, the establishment of a chemical laboratory, objects in connexion with physiological instruction, and so forth. Upon all those details, my colleagues, Professor Sullivan and Professor Hennessy, will be able to give much more detailed information than I possess. An extremely valuable and unique library, the Ringseis Library, was purchased through my intervention for a considerable sum of money from the Rector of the University of Munich. Professor Von Ringseis's library was in process of collection for about 300 years, and is very valuable in a historic point of view, and is brought up to a recent period in all scientific works, bearing principally on physiology and medicine.

13,376. Is that chiefly a scientific library?—It is in great part a scientific and in great part a medical library. A very considerable part of the fund was expended in what was always in contemplation in the University, namely, to establish very extensive University buildings, with museums and chemical laboratories, and a physical cabinet with astronomical instruments, and all appliances, up to the scientific requirements of the present day. In the year 1857–58 the Faculty of Science, of which my two colleagues, who are present, and I were members, drew up a report, which was presented to the authorities of the University and by them to the Board of the University, which consists of the Cardinal, the four Archbishops, and the other Bishops of Ireland; and I would beg leave to hand that report in as a part of my evidence (*delivering in the same*). It contains the views of the Faculty of Science as to the objects requisite for the institution of a complete University system of instruction in science. Taking action upon the views contained therein, the board of bishops, at the instigation of the rector, and acting upon the suggestions of the faculty, then set about founding the University in buildings suitable to the original intentions, and a large piece of ground was taken in a suitable situation on the north side of Dublin, containing 34 acres, which was purchased at a considerable outlay. Plans were then drawn up by a most eminent architect, Mr. McCarthy; and, if your Grace will permit me to show what was in contemplation, and what we still hope to accomplish, I will exhibit to the Commission the full plan and the specifications of the University buildings as then contemplated. The foundation stone was laid on the 20th July 1862, and buildings were projected, to which it was contemplated that an expenditure ultimately reaching a couple of hundred thousand pounds should be devoted. As the Commission will see, a building of very large and capacious dimensions was contemplated in that plan (*delivering in the same*). The foundation stone was laid amidst a vast concourse of people, and one of the most important public meetings that I ever witnessed in Ireland or elsewhere. The operations were proceeding, when, unfortunately for us, an Act of Parliament was obtained by which a railway company got power to run through the ground, and that so entirely interfered with our plans that the project, after a lengthened litigation, had to be abandoned at a very material loss incurred to the University of a large part of its funds. That railway company never carried out its operations beyond sinking a shaft, and eventually, when years elapsed, the University had to abandon the suit against the railway company, and lost a very large amount of their funds, I am afraid to say how much, but certainly I should be very much within the mark when I say that fully 5,000*l.* was lost upon that occasion, and in that project, and what was also of equal if not of greater importance, very much valuable time was lost. The thing spun on and hung on, as those things will do, before the courts in Ireland, and ultimately on appeal, and after many valuable years were wasted, the University had eventually to abandon that project altogether. It has since then extended its operations upon the site that it at first originated in. On the south side of St. Stephen's Green, in the city of Dublin, it has succeeded in acquiring a large frontage of 270 feet, by about the same measurement in depth, on which it is contemplated to erect extensive University buildings. Recently also we met with mishaps in one or two ways. We acquired in connexion with that site a much larger piece of ground, but when that was being taken possession of, and plans were made for erecting museum galleries and lecture halls upon it, it was found in the Landed Estates' Court that a flaw existed in the title, in consequence of a right of way passing over it, so that the sale was quashed by one of the Judges of the Landed Estates' Court, and that purchase had to be abandoned. The University, however, has the command of a site of 260 feet by 270 in the most conspicuous and one of the best positions in Dublin, and in proximity to ground which may ultimately be obtained; and I am authorised to state that it is in contemplation, on the part of the University, to erect very extensive buildings on the present site.

13,377. Have you erected any buildings there already, or have you made use of the buildings that you found already in existence?—We have made use of and partly modified large existing mansions formerly occupied by the then resident nobility of Ireland, and we have converted them to such uses for University purposes, as we have been able to do temporarily. It has been in contemplation to establish an astronomical observatory on a full footing, adequate to the requirements of that branch of science in the present day.

13,378. Have you funds in hand now for proceeding with your buildings?—There is a certain portion remaining of the corpus of the original fund, the precise amount of which I could not at this moment specify. The University possesses in value the mansions which at present exist, which are of considerable commercial value; and it also possesses the residue of the original corpus of the fund collected.

13,379. Do you contemplate that it will be necessary to pull down the existing buildings which you are making use of, whenever you proceed to erect the University on its full scale?—We do.

13,380. Have you at present sufficient space for lecture rooms?—We have very handsome rooms, formerly the reception rooms of very spacious mansions, which are used for that purpose. There is also a temporary structure in the rear, which is used for a lecture room; and, independently of that, I may mention incidentally that the University possesses a building for a medical school, quite apart, in another situation.

13,381. Are there any buildings which you at present use as museums and laboratories?—There are.

13,382. And are they tolerably adequate for the purpose?—They are tolerably adequate, but of course it would require very considerable extension indeed to meet the modern requirements, but upon this point Professor Sullivan and Professor Hennessy will be able to give much more detailed information.

13,383. Are the Commission to understand that you have at present sufficient space at your disposal, if you had the funds to proceed with the buildings?—We have space sufficient to put up very considerable museum galleries, lecture theatres, a physical cabinet, and study halls; the space is one of 270 feet frontage and 260 feet in depth.

13,384. And can you make use of the whole of that for building?—Yes, we can make use of the whole of that space.

13,385. Have you altogether abandoned the site of 34 acres to the north of Dublin?—We have, because, although the railway company is in abeyance at present, I believe it still possesses the power under its

R. D. Lyons, Esq., M.B. T.C.D.

18 July 1872.

Act of going on with its work at any time, and it would so completely subdivide the ground and raise an embankment which would so disfigure it, that it would be totally unsuitable for the purposes for which we originally contemplated it.

13,386. Some of your professors, I believe, have been distinguished as investigators of science?—Some of them have contributed papers on their special subjects, which I believe I should be justified in saying have been received as very important by the Royal Society and other bodies, and their writings can be found by name in the Royal Society's catalogue, without troubling the Commission with a lengthened account of them; but if it should be thought desirable I could undertake to have presented as a part of my evidence a full statement of the original writings of the various professors. There are some points in connexion with the mode of instruction which are unique and important, at least they were so in their day. I think we may claim to have the credit of introducing originally the teaching of certain now well-recognised and important subjects. I may perhaps be permitted to mention to your Grace that I was myself the first person to deliver a course of lectures on the microscope and its uses in physiology and physiological anatomy, and general investigations in Ireland, and my lectures were then attended by several gentlemen, amongst others, by one of my now colleagues, the professor of physiology in the School of Medicine, Dr. Hayden; and to him is certainly due the credit of being the first to introduce into the teaching of physiology in the School of Medicine, the application of the use of the microscope, and the practical instruction of the students in the use of the microscope in connexion with physiological lectures. Histological observations have been conducted from the foundation of the school by Professor Hayden and his colleague Professor Cryan, who are joint professors of physiology in the Faculty of Medicine, and I think it may be stated without fear of contradiction that they were the first to introduce practically the use of the microscope in the teaching of physiological and anatomical, including histological science in their course of physiology. Dr. Hayden himself is a distinguished contributor to that branch of science, and his writings will be found also in the catalogue of the Royal Society, so that, perhaps, I need not further refer to them.

13,387. (*Professor Huxley.*) I presume that you mean the first in Ireland, and not the first in the world generally?—Certainly not. I mean that we were the first in Ireland, and the same observation applies, of course, to my own lectures as being the first in Ireland in connexion with micrology, a term which I believe I introduced.

13,388. Would you wish to give any further explanation with regard to the use of that term?—I do not know that it is worth speaking of, but I believe that I was the introducer of the term, such as it is, good or bad, in connexion with the annals of micrology, originally published and for some years continued, until I went to the Crimea, in the "Medico-Chirurgical Review," then under the editorship of Professor Parkes. The pamphlet which I will now hand in as part of my evidence also contains an account of the Faculty of Science, and the scheme for studies and examinations for the licence in science (*delivering in the same*), and this contains in a more convenient form a list of the prizes, exhibitions, and medals, with the results of examinations, &c. (*delivering in the same*).

13,389. (*Chairman.*) Have you a large number of students in the School of Medicine?—In the School of Medicine, comparing one school with another in Ireland, we have a very considerable number. Our School of Medicine has been very successful. We have sometimes had considerably over 100 students, and we had last year as many as 80 students, which, for an Irish school, is a considerable number. Our students have, many of them, attained distinguished positions in the public service, and several of our students who passed through the Faculty of Science have also attained important public appointments, and some of them now fill appointments in connexion with the Royal Engineers and other branches of the public service. I may mention to your Grace that we have been almost the first in Ireland to enforce in a very rigid manner the attendance upon lectures. A system, not very commendable, prevailed of issuing certificates on a very loose attendance, and it was part of the object which we have ever held in view to enforce a rigid attendance, with the object of affording the students the fullest possible means of becoming practically acquainted with their scientific studies.

13,390. Do you find any difficulty in enforcing the amount of attendance which you think desirable?—Not now, because our rules are pretty well known, after some years' experience, that no certificates for sham attendance are given. I may be allowed to say here that we labour under very great disadvantages. We have been working up hill and struggling, I hope manfully, against very serious difficulties. The want of an endowment and the difficulty of procuring funds, where there are so many calls upon the public as there are in Ireland, have put great difficulties and many obstacles in our way. However, I think we have battled on so far, that we hope to float into that good time when we shall show ourselves to be entitled to full state recognition, and to a share in those endowments for the cultivation of science which are now given to most teaching bodies. The absence of the power of conferring degrees has also worked against us in a very important manner. Of course it will be readily understood by your Grace and the other Commissioners that the fact of attaining a degree in an University is one of the most potent incentives to students to flock to the University, and no matter what inducements in the way of scientific teaching are held out, where a degree cannot be got in the end to cap a student's labour and to present to the public as proof that he followed an University career, it adds enormously and incalculably to the difficulties which any teaching-body so circumstanced has to contend against. We have felt that want immensely. We have constantly addressed successive governments on the subject, and as it is a matter of public history and notoriety, you are aware that the subject has been in one way or another before the public now for many years, and some tentative efforts towards its solution have been essayed by more than one government.

13,391. Has the University adopted any title by which to designate the students who have passed through their course of instruction in a creditable manner?—We have. We have adopted the title of scholar for those who have reached a certain degree of proficiency in examination, and the title of associate of the University for others, but those titles have not been found to be practically recognized by the public. The public do not understand the introduction of new terms; they are very slow to take up new terms.

13,392. They are not found to be equivalent to the ordinarily recognised degrees?—No, they are not. The University degrees of B.A., M.A., M.D., and LL.D., are thoroughly well known in the public mind, and any teaching body that cannot confer those degrees on students after a four or five years' severe course of studies, labours under an immense disadvantage. It is overweighted in comparison with any other body, and is not running on even terms with it.

13,393. (*Sir J. P. Kay-Shuttleworth.*) Do any of the bodies which confer a degree recognize attendance upon the courses of instruction in medicine, for example, as entitling a student to come in for examination?—I may state, with reference to that point, that all the medical bodies, I think I may say without exception, recognise the lectures in the School of Medicine of the Catholic University as qualifying lectures for the various medical and surgical licenses, and their value is fully recognised by the Universities; but, of course, in the case of those Universities that require a full attendance on their own curriculum for their own degrees, they are not recognized; but they are recognized by the Colleges of Surgeons of England, Scotland, and

R. D. Lyons, Esq., M.B. T.C.D.

18 July 1872.

Ireland, and by the Colleges of Physicians of England, Scotland, and Ireland, and by the Edinburgh University, and some other Scotch Universities, and by the University of London.

13,394. Beyond that, you would desire that you should yourselves have the same power, which you do not at present possess, in relation to degrees?—Yes.

13,395. (*Professor Smith.*) Does the attendance at courses in arts give no privilege with regard to the degree by any other degree-giving body?—Not any, except whatever it may do with regard to the London University, which treats all public and private teaching alike.

13,396. (*Professor Stokes.*) In the paper which you were so kind as to place in our hands, relative to the Catholic University of Ireland, I find a statement in one place, "In order to become formally students and "consequently members of the University and en-"titled to all its privileges, the candidates for admis-"sion must place themselves under its guidance and "discipline." It is also said that "each candidate "must be recommended by the person who last had "charge of his education, and by his bishop or by one "of the clergymen of his parish;" and it is also stated with reference to extern students, or those who live with their friends in Dublin or its neighbourhood and attend the University lectures, that "They are re-"quired to be present at the University Mass on Sun-"days and Holidays, to approach the Sacraments of "Penance and Holy Communion, and to lead good "Christian lives." It would at first sight appear from these statements that all the students of the University, although they might not actually belong to the Roman Catholic religion, were required to conform, to a certain extent, to Roman Catholic observances; will you have the kindness to explain to the Commission how that is?—I should begin by saying, that, of course, the University was founded for the purpose of affording facilities for education and rewards for scientific research, to persons of the Catholic religion, they being those who, in Ireland, were up to that period without the means of such education, and of such scientific advancement; and those rules which I have handed in are framed specially for the discipline and guidance of students of the Catholic persuasion, but it has been at all times clearly held in view, that, whilst that discipline was to be applied according to the rules of the Catholic Church to students who were Catholics, the education of the University was to be open to all comers who chose to attend its lectures, and that all comers, without regard to their religion, should be competent to compete for the prizes and exhibitions of the University. And I can state, as a matter of fact, that persons other than Catholics have competed for and have obtained and have enjoyed the honours and emoluments of the University, and that no interference whatever has been sought with the religious persuasion or religious discipline of those students; nor has it been attempted in any manner to bring them under the discipline or religious instruction of the University. If they chose, of their own free will, to attend any course of instruction in the University, be it religious or otherwise, they would not be excluded, but it has never been sought to enforce the religious discipline of the University against students who were of any other persuasion than Catholic. And I repeat that, as a matter of fact, others than Catholics have filled places of emolument in the University, and we should be very glad to see others coming amongst us, and I have no doubt at all that we shall have them, because I believe I shall be correct in saying that since the foundation of the University there has been scarcely a year in which some one or more students have not for some reason or other, as through preference for some particular professor, attended the classes and competed for the prizes and emoluments of the University. Perhaps I might be allowed to supplement that by stating that that point was most distinctly raised and fully discussed at the Rectorial Council of the University, and decided in the manner in which I now mention to the Commission. Not very long since, some question having been raised about the matter, it was decided in the manner that I have mentioned. I may point out that it is only in a foot note such exemption is provided for "Roman Catholics and other Dissenters" from the rules of Trinity College, Dublin, thus absolutely expressed, "All students are requested to attend Divine "service in the College Chapel, both on Sundays and "week-days." (See Dub. Univ. Cal. 1871, foot note a, p. 33.) I may mention also as a matter within my own knowledge from what I believe was in the contemplation of a most eminent divine, Dr. Newman, at the foundation of the University, that as the highest standard of excellence was insisted on in the selection of professors and lecturers in the various departments of science, in case, for the time, no Catholic was to be found fulfilling these requirements, no one pre-eminently qualified, and otherwise unexceptionable, should be excluded from teaching a Chair in the University on account of his religion; and Dr. Newman in conversation with me distinctly stated that he would not exclude any professor in consequence of his religion. It did not happen that there was any blank to be filled up that could not be filled up, and that was not filled up, by one of the Catholic religion who was deemed competent to fill the office.

13,397. You would except, I presume, the Theological Chairs?—Of course, excepting the Theological Chairs always.

13,398. (*Professor Smith.*) With regard to that last point, I understood you before to state that at one time it had been contemplated that the professors of the University in other faculties than that of Theology might not necessarily be Catholics, but I wish to ask you whether that point still remains open, and I would, in connexion with that, direct your attention to an extract which I will read from the address of the Very Reverend Rector at the solemn inauguration of the session of 1867–1868, at page 142 of the Calendar for the year 1869: "Our Faculty of Medi-"cine does not exclude Protestant students from its "lectures, but neither do our other faculties. We "recommend or prescribe, as the case may be, religious "observances to the Catholic medical students under "our care, as well as to our students in letters or in "science; but our rules on this subject do not com-"prise those who decline to accept the teaching of "the church. But there is one point on which we "stand firm, and which equally regards our Faculty "of Medicine and the other departments of this "University; we will have Catholic students taught "by no professors save those whose principles we "know to be in accordance with the teaching of the "Catholic Church in faith and morals." I direct your attention to that because it was delivered with some authority, and appears to indicate a different conception of what would be proper in this matter from that which at one time existed in the mind of Dr. Newman?—My answer to that would be, that what I referred to was a personal conversation with Dr. Newman, and that, of course, could only be taken to convey my interpretation of his views. I do not know that there is anything in the statutes of the University which absolutely enforces what the Very Reverend Rector has defined in the passage which you have read, but I assume that it goes upon the general principle of what would be likely to be the case now, and of course the interpretation to be put upon it would be his in the one case and Dr. Newman's in the other. As I mentioned, the circumstance never arose that there was not an ample field of selection amongst Catholics, and they were accordingly appointed. Might I ask leave to put in for reference by the Commission these lectures which I hold in my hand, by Dr. Newman, having relation to the establishment of the University, and the principles upon which it was founded. They are Discourse 1, "Introductory," Discourse 9, on "Philo-"sophical knowledge viewed in relation to religion," and Discourse 10, "Duties of the church towards "philosophy," and the appendix to those discourses, which contain the main elements of all the questions

R. D. Lyons, Esq., M.B. T.C.D.

18 July 1872.

raised upon this point (*delivering in the same*). At p. 9, Discourse 1, occurs the following passage, "Nay, not only may the true philosophy of education "be held by Protestants, and at a given time, or in a "given place be taught by them to Catholics, but, "further than this, there is nothing strange in the "idea that here or there, at this time or that, it should "be understood better, and held more firmly by "Protestants than by ourselves."

13,399. (*Professor Huxley.*) Of course we accept your interesting statement about what the views of Dr. Newman were in relation to the University, but the only official document which we have to go upon is this programme issued by the authorities of the University and under the sanction of the University, and I think you will admit that reading this alone, without any such comment as you would supply yourself, would lead to the conclusion that only those persons were admitted to the discipline and honours and advantages of the University who were ready to comply with the regulations laid down here—that is what appears upon the face of this document; and may I ask, supposing a Protestant student to attend the University, by what authority would he be excused from obedience to the particular regulation which Professor Stokes has read?—By the authority of the rector.

13,400. Would he have to make special application to the rector for that purpose?—It is the recognised practice; and the fact of reporting himself as a Protestant *ipso facto* excludes a student from religious discipline. A letter of character is required with each student, and if from a Protestant clergyman it would be accepted at once.

13,401. But there is nothing in this document to inform the public about it?—No, for the reason that I mentioned before, that the University was founded, and this programme was drawn up, for the benefit of those who alone stood so very much in need of assistance in education, viz., the Catholics of Ireland.

13,402. But as matters stand now, it is quite clear that at any future time, in referring to this document as being an authoritative exposition of the constitution of the University, it would be possible for the authorities of the University to say that the regulations were always such as to exclude any but Catholic students from attending, and that if any Protestant students have been allowed to attend it has been a matter of pleasure and favour on the part of the rector for the time being, but the act was not recognized as an authoritative or legal one by our statutes?—I do not think that that would be so, and for this reason, that the question was raised and authoritatively decided at the Rectorial Council. The principle involved was further publicly affirmed in the Memorial to the Prime Minister from the rector, professors, officers, and students, present and past, of the Catholic University, under date February 7th, 1872, in which occurs the following passage: "That although this University was "founded, and its statutes framed for the Catholics of "Ireland, it imposes no religious test on students who do "not profess the Roman Catholic faith, and does not re-"quire them to attend any instruction, or comply with "any observance of the Roman Catholic religion; "and, as a matter of fact, non-Catholic students have "not only received its instruction, but have also "enjoyed its prizes and emoluments."

13,403. Is there any public record of that?—It is on record in the Council books.

13,404. But no official notice of that fact was ordered to be entered upon the programme, which is the only thing that the public have to go by?—No, because we do not hold out public inducements to others than Catholics to come amongst us. We are glad to see them, and many of them do come for reasons that I have mentioned before, selecting the mode of instruction of a particular professor, and so on, but the object of the University, from first to last, was to supply the wants of the Catholic population in Ireland, for whom no University training within the limits that they considered necessary was provided, and to whom no emoluments in other Universities were open.

13,405. I can perfectly understand the condition of the University on that footing, as in the first place being not only intended for Catholic students, but confined to them, which is what appears upon your programme, whereas what I venture to point out, and what I presume you will acknowledge yourself, is the fact that so far as the official programme is concerned, there is no official recognition of that broader use of the University which you say comes out as a matter of practice?—We have avoided putting any such thing in the programme, and for a main reason, most essential in Ireland, that we should avoid any, even the remotest appearance of a desire, to establish a propagandism. That would at once raise, in the particular constitution of the public mind in Ireland, a host of difficulties in our way, so that we do not address ourselves publicly to any but Catholics. The object of the University is to provide for Catholics that which they had not before and which others had elsewhere, but if others chose to think that we can teach better, or that we hold out stronger scientific inducements of one kind or another, we are glad to receive them, and as the practice is established it could not now be departed from; it is a settled practice, and it is officially recognised by the act of the Rectorial Council. But I think you will see that we are only acting within the limits of prudence, in the state of the political atmosphere in Ireland, in avoiding on our part anything like propagandism.

13,406. Might not, on the other hand, the very great reputation for liberality which the University would have if it were publicly and officially stated that students of all kinds had access to its teaching and its honours, be a very important counterbalance in the other direction?—I do not think that it would have so much weight for good as it would certainly have weight for evil against us, in the state of feeling in Ireland. There is nothing that raises suspicion in Ireland so much as anything at all approaching to the appearance of propagandism, and most justly so. Nothing has been used, as you are probably aware, more against the University of Dublin than the allegation that at one time, unfortunately, inducements were held out to persons to leave their religious persuasion, and, for the sake of place and emolument, become members of the Established Church. That is one of the most fatal objections which has been raised to the system of the University of Dublin, so that we for all these reasons have avoided it. I am quite sure that the wisest policy of the University would be in the future, as in the past, to avoid addressing itself in any way by solicitation of any kind to any other body than the body of Catholics in Ireland. Of course every one will clearly understand that it is for the Catholics that this institution was founded; but we do admit Protestants, and this has been stated in the most public and official manner by the rector in the address just cited (13,398), which was delivered in the presence of the whole University body, several of the Catholic prelates, and a large assemblage of the general public.

13,407. So that we may take it that the Catholic University has in practice an amount of liberality for which it would get no credit on the face of its programme?—Quite so.

13,408. Is there anything to prevent a student of the Catholic University from obtaining a degree in the Queen's University in any faculty, always excepting theology?—The Queen's University has recently modified its arrangements very considerably, yet I believe I should be correct in saying that it would be absolutely impossible unless he personally attended lectures in one of the Queen's Colleges. I speak under the correction of my colleagues, who are in some respects more familiar with points of this kind than I am, but I believe that a student presenting himself for a degree in the Queen's University, and taking up the certificates of our lectures as his qualification, would not be admitted to a degree in arts or science. In medicine, unless he also had certificates of attendance for one

R. D. Lyons, Esq., M.B. T.C.D.

13 July 1872.

session, at least, in one of the Queen's Colleges, no student of the Catholic University could obtain a degree.

13,409. In fact, the Queen's University in Ireland stands on the same footing with regard to persons of all religious bodies as the London University does here?—It does to some extent only, and in the limits just defined; but there was a question connected with an important movement, a movement in relation to a supplemental charter, with regard to which Professor Sullivan will be able to give much more strictly accurate information than I could pretend to do, as he is a member of the senate of the Queen's University.

13,410. Supposing that the degrees in the Queen's University were open to every one in the same way that the degrees in the London University are open to every one, are you aware that many Catholic colleges in England send their students to the London University to take their degrees, and supposing that were the case, would there be any objection on the part of the authorities of the Catholic University to such degrees?—I think there would; there would certainly be the objection on my own part that I do not think the system would at all sufficiently or necessarily provide for the education of the student, which I hold to be a most important preliminary to his getting any degree, and I believe that where you have only an examining body, which position the Queen's University would then hold, there would not be at all the same paternal interest to look after the education of the students, as there is necessarily in the case where the University which grants the degree is also the teaching body.

13,411. But you are aware that the conferring of a degree by the Queen's University would not interfere in the slightest degree with any amount of paternal guidance or teaching which the Catholic University might choose to carry out?—But whose interest would it then be to see that the education was carried out? Provided that a student answered a certain minimum or maximum number of questions, whichever the case might be, when he is sent up for his final examination, it would not be the object of the examining University to see that the student's education was carried out diligently during the period of his studies.

13,412. You are doubtless acquainted with the influence which the University of London has exercised upon medical degrees in this country. The University of London is simply an examining body, yet by the high standard which it requires from candidates, it has most effectively reacted upon the teaching in our medical schools. It has greatly increased the excellence of the teaching and the diligence with which students have been taught. There being in England this reaction of the examining body upon the teaching bodies, I do not quite see for the moment why there should not be the same reaction of the examining body upon the teaching bodies in Ireland, supposing that relation to exist?—If I may say so, you take a great deal for granted which I should not grant in the first instance, and in the next place in so far as the London University has operated beneficially, I hold that its operation which has extended over all those years would have been infinitely more beneficial if, besides being a superior examining body, it had also been an educational body, closely following up the teaching of the students *de anno in annum.*

13,413. I understand that your objection to the conferring of degrees by the Queen's University is that such degrees would be imperfect for the purpose of the higher training?—Certainly.

13,414. (*Professor Smith.*) It is the case, is it not, that the Catholic University does confer degrees in theology?—It confers degrees in theology, and if you care to have my private opinion I believe that it has as good a function for the purpose of conferring degrees in other faculties as many if not all of the older universities in this kingdom. It derives its power from a papal rescript. You will find in the Blue Book report, of 1833, that several of the Scotch Universities originally derived their powers of conferring degrees from the same source. What the condition of things now is as compared with then, not being a lawyer, I am not prepared to say.

13,415. What is the distinction taken between the degrees in theology and the degrees in arts, or in medicine, or in science; does the Catholic University claim the right to do the one and not claim the right to do the other, as that at present seems to be the practice?—That certainly is the practice. The University has in this matter acted with a laudable discretion, not desiring to raise any question which would bring it into collision with the privileges or authority of the Crown within these realms.

13,416. (*Sir J. P. Kay-Shuttleworth.*) Observing that you make a great distinction between the functions of an examining body, and the functions of the educational body connected with the Catholic University, and that you attach great importance to the influence of a teaching body upon education as distinguished from that of an examining body, I would venture to ask you whether your views in that respect would be in any degree modified if the Catholic University were represented in the central examining body?—I think I may state in reply to that question that, subject to other suitable arrangements being made, and if such representation on the central examining body were a fair and adequate one, that is if there were a due share of weight upon any such body given to the representatives of the Catholic University, I should, for myself personally, think that a safe solution of the difficulty. I do think it is one which, subject to arrangement of details and proper safeguards, would be an acceptable one. In point of fact there is but one of two solutions open; either that of the Crown stepping in to give direct power to the Catholic University to grant degrees; or that of giving the Catholic University a representative element with a due and proportional weight to the number of the population that it represents, on the governing board of some central body which would be enabled by the Crown to grant degrees.

13,417. Under that view it would be possible for the various teaching bodies to be in some way federated together in a kind of federal relationship to the central examining body in which they should be represented?—Always with the safeguards which I have before referred to, of a proper proportionate representation, I am of opinion that it would be a safe and equitable, and I would even go the length of saying, probably a welcome settlement of a very difficult question.

13,418. (*Chairman.*) Is there any addition that you would wish to make to your evidence?—There is one point which I should like to mention. An impression may perhaps have been produced from something that I or others may have said, that there was not a very ample field for such a body as the Catholic University of Ireland to work upon in the way of education. Some years ago I took a great deal of trouble to investigate this particular point, and produced some statistical results to show that we had a very large body of young men in the country who, having regard to the probable position and means of their parents, were undoubtedly in a position to be able to avail themselves of an University education, provided that the proper requirements were furnished in an institution like the Catholic University, which would have the confidence of the public and of the advisers of the public. If you would allow me to add to my evidence in print, I should be glad to put in the figures in an appendix, because I think it is important that it should go to the public that there is ample work remaining to be done. It cannot be said that the existing Universities in Ireland educate, or grant degrees, at all in the proportion that would be natural to the circumstances of the population. A variety of reasons concur to make that so, and one of them, I might be permitted to say, is that the only University which has the confidence of the public at large, and of those who guide the public, has not those privileges which would attract students to its halls; but I have no doubt, and I think I should be able conclusively to show the

R. D. Lyons, Esq., M.B. T.C.D.

18 July 1872.

Commission, that there is a very large number of the University class of young men in Ireland who do not receive but who ought to receive an University education, and that they do not come forward in the same proportion as others do elsewhere. The main reason in my opinion for that is, that for one reason or other our existing University institutions have not the confidence of the public, and that the only institution which has the confidence of the general Catholic community in the country and of their advisers has not those advantages to offer to them and those facilities for education, and those powers of conferring degrees which would make education practically valuable to those young men who require it. Not only do a number of young men go to the professions without an University education, but a number of young men grow up in the various classes of society in the middle rank, the children of parents of ample means, who do not receive what they ought to receive, and what it would be very beneficial to them and to the country at large that they should receive, namely an University education. I do not believe that it is any want of adequate funds that prevents a sufficient number coming forward out of the very large number that I believe to exist who are in a position to require an University education, and to maintain themselves in proper respectability during the progress of their University studies. I think it is an important element of the case, and one which should be understood, that there is ample work for the Catholic University to do; that it does not exist, and it is not intended that it should exist, as a mere ornamental institution, to do a certain amount of select work for a particular select body; but that there is a very large and ample field ready to be operated upon, if those facilities and those inducements were afforded to the University, which would enable it to compete properly with other bodies, and to confer on such students what would be of practical value to them in life.

13,419. Have your students now an opportunity of obtaining medical degrees at the Dublin University?—Not without, in addition to following our curriculum, fulfilling the requirements of the University of Dublin, so that, practically, we do not enjoy any advantages by the University of Dublin.

13,420. Could not your medical students obtain degrees by going for a part of their course to one of the Queen's Colleges, or by coming over here to the London University?—Yes, always bearing in mind that they can directly obtain, as I said before, the licenses of the Colleges of Physicians and the Colleges of Surgeons. All over the kingdom these bodies recognize our teaching as fully adequate to their requirements, and on the same level as that of all other teaching bodies, but no actual degree can be conferred.

13,421. (*Sir John Lubbock.*) The University of London holds examinations in Ireland, does it not?—It holds examinations, but those examinations are the preliminary and not the degree examinations; no degree examinations are held by that body in Ireland in medicine.

13,422. (*Professor Smith.*) The London University holds examinations in Ireland for first and second bachelors of arts and bachelors of science, does it not?—Yes.

13,423. (*Chairman.*) Is there anything further which you would like to state to the Commission?—I would wish to observe that the position of the professors of the Catholic University is one of great independence. There views have been always met with the greatest liberality, so far as the means at command would permit. The pursuit of science has been at all times in every available manner promoted. I may be permitted to mention, in illustration, that when I undertook the mission to Lisbon in 1857 to investigate the yellow fever, the Board of Bishops voted me a liberal sum to cover my expenses; while the Government of the day which recognized the value of my labours and investigations by publishing my report as a Parliamentary Blue Book by command of her Majesty, in no other manner contributed to the undertaking or recognised my services. In conclusion, I may further state for the information of your Grace and this Commission, that it is my deliberate conviction that any settlement of this question must comprise two main conditions:—1st. That any contemplated University Board should be one presiding over all the Universities of Ireland, and dispensing the honors and rewards in prizes, scholarships, exhibitions, fellowships, &c., through an examining board under its control, each University College preserving its distinct autonomy. 2nd. That the Catholic University, in its then collegiate capacity, should share in the public endowments alike with all the other then collegiate bodies. Our principle is fair competition on equal terms, and under equal weights. "Endow all, or disendow all." I believe an equitable settlement on the above basis could be easily arrived at, if the University Board were fairly adjusted to the proportionate wants of the parties interested in higher education in Ireland.

The witness withdrew.

WILLIAM KIRBY SULLIVAN, Esq., Ph.D., examined.

W. K. Sullivan, Esq., Ph.D.

13,424. (*Chairman.*) You are Professor of Chemistry, are you not, in the Catholic University?—I am.

13,425. And also Professor of Chemistry in the Royal College of Science, and, I believe, Secretary of the Royal Irish Academy?—Yes, and I may add with reference to a question which was raised in the examination of my colleague, Dr. Lyons, that I am a member of the Senate of the Queen's University.

13,426. Will you have the goodness to describe to the Commission the organization of the Faculty of Science in the Catholic University?—The course of instruction in the Faculty of Science may be best understood by the classification of the subjects that are supposed to be included in the entire curriculum of arts and science, which is to be found in the University Calendar, a copy of which I hand in. The scientific subjects will be found in the last column of the table. Some of those subjects are common to the Faculty of Arts, or, as we call it, the Faculty of Philosophy and Letters, and the remainder belong to the Faculty of Science, properly so called. The scheme of studies includes, as you will see, the entire of the mathematical sciences, the physical sciences, including astronomy, and chemistry, chemical physics, and the entire of vital physics, as we describe physiology in its widest acceptation; in fact, the whole range of the mathematical and physical sciences; and those subjects were to be taught by a professor of mathematics, a professor of physics or, rather, natural philosophy, a professor of chemistry, a professor of geology and mineralogy, professors of the natural sciences, usually so called, namely botany, and zoology, and of general physiology, as a separate subject, and ultimately, perhaps, if we had been able to carry out the organization fully, a professor of astronomy. I should also add that there were to be certain Chairs of applied science connected with the Faculty, such as architecture and engineering. At present, the Chairs that are established are those of higher mathematics, natural philosophy, chemistry, physiology, geology, and architecture. The Chairs of natural history and of geology have not been filled up. There is, however, a lecturer on botany.

13,427. Are the professors also the examiners, or do you call in persons who are not professors to examine?—From the very establishment of the University, the distinction between examiners and professors was fully recognised. In practice, it is the professors who do examine, but they are not examiners because they are professors, and, whenever we could, we have always had persons not connected with the University, or at least not connected with our Faculty, associated with us.

W. K. Sullivan, Esq., Ph.D.

18 July 1872.

13,428. Could you give the Commission some information as to the system of examination in the Faculty of Science; in the first place, how frequently do the examinations occur?—My answer is to be understood as applying to my own subject principally, and my colleague, Professor Hennessy, will be able to inform you as to his department. First, as to the general question of examinations, so far as the physical sciences are concerned, they have been taught and examined in practically, to a very considerable extent, wherever they admitted of it; and I may incidentally say that it was through the Catholic University that practical chemistry, that is laboratory work, as distinguished from mere lectures, was introduced into the medical schools of Dublin. Previous to the establishment of the laboratory of the University, practical chemistry, as taught in medical schools, consisted of a short course of lectures, illustrated by a set of experiments made by the professor at one side of the table with his students looking on on the other side. There was no exception in this respect, so far as Dublin was concerned; not even in Trinity College. The latter had a laboratory to which a student might go on paying a certain fee, but the certificate which he got, and which the Licensing Boards required, if he happened not to have been a student at the University, was merely for attendance at lectures, and not for the practice of chemistry in a laboratory. I am glad to learn that they have now established a laboratory for the purpose of teaching real practical chemistry to the medical students. In my class a medical student, instead of having to attend one hour a day for three days a week during three months, as the Medical Licensing Boards require, may attend from 10 o'clock to 4 every day in the week, except Saturday, and I am glad to say the majority do attend. The professor is supposed to be always there, and to assist in superintending the work. I hold weekly examinations of my class in general chemistry, and terminal examinations at the end of each session. At these, and the examinations for the gold medal, and exhibition in the combined subjects of vegetable and animal physiology and chemistry in the Faculty of Medicine, and of chemistry, crystallography, and mineralogy, &c., in the Faculty of Science, the examination is conducted by written papers, *vivâ voce*, and practical demonstrations with the microscope. The examination in practical chemistry consists altogether of laboratory work. In the examination just concluded for the gold medal in the combined subjects of practical chemistry, materia medica, and medical jurisprudence, the chemical part lasted nearly four entire days. As I have performed to a considerable extent the functions of professor of mineralogy and geology, I may add that the same observations apply to the method of teaching those subjects and of conducting the examinations in them. The lectures are illustrated by specimens, and instruments, which the students are taught to examine and use, and I give field lectures. The examinations are as far as possible practical, the student being asked to determine and describe minerals and rocks, and measure the angles of crystals and determine the crystallographic forms.

13,429. Do we understand that you lecture in mineralogy and geology, as well as in chemistry?—I do.

13,430. Can you give the Commission any information as to the number of lectures which you usually deliver in the year?—The subjects of geology and mineralogy belong to the fourth year in our course, and as it is very difficult for us to get students to remain four years, it sometimes happens that I am not called upon to give any special course to such a class. Some years there may be several students requiring those subjects, and other years none. When I have no class of regular fourth year's students I may have several other students attending the laboratory who desire instruction in those subjects, and I give instruction to them. I should say, generally speaking, I give about 40 or 50 lectures in mineralogy, exclusive of those that I give upon geology. Mineralogy in our system of classification includes a considerable portion of what is usually taught as geology, namely, the metamorphosis of rocks and metamorphic action generally, while geology is restricted to the history of the crust of the earth, and, so far as I can go into it, palæontology.

13,431. Do we understand that no one is permitted to study geology and mineralogy until he has reached his fourth year?—No one is compelled to do so, but anyone may attend the lectures who chooses. There is no rule regulating it, but, of course, if there be a fourth year's student, it comes into his course, and he would necessarily be obliged to attend it.

13,432. Are the students who attend your lectures in chemistry chiefly medical students?—I have occasionally a considerable number of arts students; many of those who afterwards become medical students, attend me first as arts students, but the majority of students in the University who study chemistry are necessarily medical students.

13,433. Can you give us some information with reference to the relations of the Faculty of Science to the Faculty of Arts?—I have to some extent pointed that out in explaining the general scheme of studies given in the University Calendar, and in mentioning the subjects that are taught in common in the two faculties. The whole scientific portion of it is in some sense conjoint. Physics and mathematics, for instance, are common to both faculties. The lectures of the professor of physics, and of the professor of chemistry, are also common both to the students in the Faculty of Arts and the students in the Faculty of Science, and I perhaps may be allowed to add that originally it was intended, and we carry it out as far as possible, that the student should only enter the Faculty of Science after having spent two years in the Faculty of Philosophy and Letters, and that the bifurcation in the studies of students in Arts should take place at the end of two years. He may then elect to continue in the Faculty of Philosophy and Letters, or he may become a student in the Faculty of Science. Hence, mineralogy and geology, and those other subjects which form the second year's course in the Faculty of Science, necessarily come into what would be the fourth year of a student's undergraduate course.

13,434. To most of the students who have become students in the Faculty of Science, is there only one line of study open to them, or have they also a certain amount of choice as to the subjects which they will study?—One of the documents which Dr. Lyons, I think, put in will show the manner in which that is done. The document only has been put in, but no explanation I think has yet been given. The scheme of examinations in that faculty embraces, as a necessary element, elementary mathematics and experimental physics, general chemistry, and the elements of physiology. A student, if he passes creditably in the subjects that I have named at the end of the first year, then enters upon the second year's course, the subjects for which are higher mathematics, mathematical statics and dynamics, cosmical physics, chemical physics, that is, the relations of chemistry to natural philosophy, general physiology including systematic botany and zoology, physiological chemistry, mineralogy, and geology. Those are the subjects which he is bound to attend, but he is examined only in mathematical statics and dynamics, in the elementary portion of cosmical physics, in chemical physics, in general physiology, and some mineralogy and geology, but the examination for honours allows him to select one of four or five different groups of subjects. He might confine himself exclusively to the higher mathematics and mathematical and cosmical physics, or he might take cosmical physics and mathematical statics and dynamics or experimental physics, or he might take experimental physics, theoretical chemistry, and chemical physics, or he might take simply chemistry and the related portions of mineralogy and geology, or, finally, he might take physiology and theoretical chemistry, chiefly organic. So that he is allowed, after qualifying himself in the elementary portions of a general

W. K. Sullivan, Esq., Ph.D.

18 July 1872.

scientific course, to select, in going in for honours, any one of those five groups.

13,435. At what age do the students generally enter the University; is it about the same as in other similar Universities?—We do not take any student under 16.

13,436. Do a great number enter at that age?—Yes, but the usual age is 17 or 18, and we have occasionally older students.

13,437. Should you describe your laboratory as sufficient or otherwise?—Since the laboratory was fitted in 1856, a considerable change has taken place in the size and importance of University laboratories in Europe. We have nothing to compare with either Bonn or Berlin, but when it was set up I am able to say that it was, perhaps, the best for teaching purposes in the city of Dublin at that time, and in the plans that were laid before the Commission and referred to by my colleague, Dr. Lyons, we were desirous to bring the medical school into closer proximity with the principal buildings of the University, and to give to science, in the new arrangements, a position adequate to its growing importance. We accordingly laid out plans for laboratories up to the level of the present condition of the physical sciences, and among them was to be also a laboratory for physiological experiments, but of course we cannot carry out these plans at present, inasmuch as we have lost possession of the ground upon which the buildings were to be erected.

13,438. What can you say as to your mineral and geological collections?—I think that I have one of the best collections of minerals and rocks for teaching purposes in Ireland. It is not as extensive as others, nor does it contain as many fine specimens, but it has been selected for special purposes, and there is hardly a single portion of the whole subject that it does not illustrate properly. We have altogether about 5,000 or 6,000 specimens.

13,439. Has this collection been acquired by purchase?—Partly by purchase and partly by presentation, and, to a considerable extent, by my own work. A good deal of money has, however, been spent on it.

13,440. Are there any publications connected with the Catholic University?—With the object of creating some taste in Ireland amongst the Catholics, and especially amongst the heads of the secondary or intermediate schools, who are chiefly clergymen, and who have practically, indeed I may say now absolutely, the entire education of the middle and upper classes of Catholics in their hands, we started, at a very early period of the University, a periodical called "The Atlantis." The idea originated with Dr. Newman. It was not intended to compete with other publications of the day, but rather to bring together, in one book, all the contributions to knowledge made by the members of the University, and consequently embraced every subject which, properly speaking, belonged to University teaching. The chief object was to show the heads of schools and Catholics in general what University teaching means. One great difficulty that stands in our way in Ireland is the ignorance of what an University is, and of the value of higher education, especially of science. We did not publish it at stated intervals. It came out according as the materials accumulated, and it included every subject, not excepting theology, but theology treated in a scientific way. Four volumes and a half have been published.

13,441. Does it still appear from time to time?—Yes; the last number appeared about a year ago.

13,442. Is it conducted entirely by professors of the University?—Only two or three articles altogether have appeared in it that were not written by actual professors or persons holding some office in the University.

13,443. What difficulties has the University experienced in the way of scientific teaching?—One has been already alluded to by my colleague, and that is, the political position of the University; I have myself just mentioned the important one,—the ignorance of the value of Science which prevails; another would be, of course, the pecuniary one, which, however, has two meanings; first, our own want of funds, and next, to a certain extent, the comparative poverty of the country, a large number of the students not being able to support themselves at the University long enough to devote themselves to a full course.

13,444. What is the amount of fees, on the average, required from the students annually?—The fees are very moderate. They are practically nominal, but it is the whole expense of living in a large city which is the important item. Of course this pecuniary difficulty is also governed by another, which I have already indicated, namely, that the Catholics have been so long debarred from education of any kind that they have actually yet to learn what the benefits of a superior education are, consequently there is not a great tendency on the part of those persons who can afford to continue the education of their sons up to 20, to send them to any University or other institution intended for higher education.

13,445. (*Sir J. P. Kay-Shuttleworth.*) If scholarships were available without political or religious distinction, and simply awarded by merit, would the schools which exist in Ireland for Catholics enable them to compete on fair terms for such scholarships, to be held wherever the parents and guardians of the students might determine?—I daresay they would; but I am not myself very sanguine about the benefits which are supposed by some to come from competitive examinations of any kind.

13,446. If the emoluments had to be distributed, which should tend to remove the difficulty which you point out as affecting the poverty of Catholics in Ireland, of course some mode must be devised of distributing those emoluments which would be free from political objection, and which should be impartial in its character; can you suggest any other than one which would depend upon some examination, testing the proficiency of the candidates?—I think that there is too great a tendency at present to pay the students for learning, rather than to supply the means of teaching them.

13,447. I did not intend the suggestion implied in my question to preclude the consideration of the other object, but applying your mind simply to the question of the poverty of the students, and what you conceive to be the necessity of providing for their residing a sufficient time in an expensive city, what I ventured to suggest to you was, that any mode of distributing such funds must be politically impartial?—Within the limits you have now stated, I should have no hesitation in saying that a portion of the public funds intended for the promotion of higher education, in case they were redistributed, might be so applied, and I quite fully admit that such funds must be distributed in a way that will be open to no objection, political or religious.

13,448. (*Chairman.*) What do you suppose is the least sum annually for which a student can avail himself of a course of instruction at the Catholic University?—I can scarcely say what the least would be from my knowledge of what some have done, but I would say that a student could scarcely well live in Dublin under about 50*l.* or 60*l.* a year in any decent way. The former is the sum which a former Commission, appointed to determine the organization of the present Royal College of Science, fixed as the amount of the Royal scholarships to be attached to that institution. 50*l.* was fixed, because it was believed that that was the lowest sum that would enable a student to live; 50*l.* or 60*l.* is about what those who are accustomed to live in a moderate and economical way might manage to live upon during a session at an University in Dublin.

13,449. If the fees are so very small, how are the professors' stipends provided?—They are provided from the annual grants. Those who belong to the Faculty of Medicine have, in addition to their salaries, the fees upon certificates, which form a considerable portion of their income. The stipends of the professors of the Faculty of Letters and those of the Faculty of Science, who do not also belong to the Faculty of Medicine, come entirely from the annual collection for the Uni-

W. K. Sullivan, Esq., Ph.D.

18 July 1872.

versity, and out of whatever interest there is upon the funded property.

13,450. The funded property, as I understand, is very small? Yes.

13,451. (*Sir J. P. Kay-Shuttleworth.*) Would you state what may be the average emoluments of a professor in science or a professor in arts?—I think that those who have no additional fees from the Faculty of Medicine have about 300*l.* a year. Those who get additional emoluments, as some few of them do, both in science and in medicine, receive more, because they have fees besides.

13,452. They would make probably 500*l.*?—Scarcely that, say about 400*l.*

13,453. (*Chairman.*) I think you have already referred to the state of instruction in the intermediate schools as being very defective?—Yes, and I should like to add that this is one of the greatest barriers to the advancement of science in Ireland, whether it be in the Catholic University or the Queen's Colleges, or other institutions. Even those that possess endowments are in a very low state, but, of course, the Catholic schools, having no endowments whatever, and not having had an University to teach the heads of them any science, they do not, as a general rule, understand what science is, and they pay very little attention to it; in fact, they cannot afford, in most of them, to get persons who could properly teach any of the physical sciences, and the result is that the students come to us without any knowledge whatever of the most elementary principles of science.

13,454. (*Professor Huxley.*) Do you think that they are much worse than the English schools in that respect?—From the very little experience that I have of the English schools, I am unable to say.

13,455. (*Chairman.*) Are there any instances of good intermediate schools in Ireland?—We have many very good intermediate schools; I think we are quite on a level with many of the better class of schools in England now, both in point of buildings and other appliances. I only address my observation specially to the physical sciences, which are in a very backward state; so far as an ordinary English education goes, and Greek and Latin, and, perhaps, the modern languages, some of our schools, and indeed I may say all our intermediate schools, which I may add are in the hands of clergymen and are entirely under clerical control, are quite up to most of the corresponding schools in England in every way, both in buildings and in every other arrangement, but are defective in the means of teaching physical science.

13,456. (*Sir J. P. Kay-Shuttleworth.*) If funds were found to render those intermediate schools efficient in the matters of instruction in which they are successful, what are the obstacles to funds being found for instruction in science in those schools?—I think that the difficulty rather comes from the persons themselves who teach in those schools not having had any scientific training; that to my mind is one of the principal and most important functions which the Catholic University would have fulfilled had it been placed in its proper position; I think that not more than 5 per cent. of the Catholics of the higher and middle classes go to any other schools than clerical schools. There are about 50 of them in the country, and those schools will not, and as a matter of fact do not, come in contact with any other educational institution in the country; they have no confidence in the present University of Dublin, and I may say they are in open hostility with the Queen's Colleges and the Queen's University, and, therefore, they have no source from which to get any inspiration in science, no channel of communication with the scientific world, except through the Catholic University.

13,457. Supposing the Catholic University to regard one of its functions to be the preparation of teachers of science, would there be any difficulty in the admission of those teachers into those secondary schools which are now taught by clergymen?—I should think not; many of the clergymen themselves, I have no doubt, or those who intended to become heads of schools or teachers in schools, would necessarily pass through it, and recently a project was suggested by the rector of the University for, in fact, doing that very thing, inducing a number of those who intended to become teachers in the intermediate schools to come to the University and follow its course of studies.

13,458. Those who are connected with the Faculty of Science in the Catholic University, and who are conscious of the great defect which exists in the preparatory education, of course their influence would be used in the direction which I have suggested, in the preparation of teachers, and securing their introduction to schools?—Certainly. The teachers educated in the Catholic University, taught by its professors, would go forth stamped, as it were, by the approval of the University; and such teachers would be gladly appointed to teach in all those schools, while those from Protestant or secular institutions would never command that confidence that would enable them to effectively further the advancement of science. Already the effect of the University in this way upon many of the schools has been very great indeed. There are very few of them now that do not attempt to teach a little chemistry, and some of the elements of physics. Instead of the text books of obsolete science, and inferior text books in classics and English literature, remainders of London publishers who found a market in those schools, good text books are now in use through our recommendation. In the Calendar you will see a list of books classified for the express purpose of showing to those schools, and to the country generally, the kind of books that ought to be taken up. That list embraces not only science, but also classics and every other branch of University education.

13,459. On the other hand, I understand you to intimate that those 50 secondary schools are for the most part taught by the clergy, and that there would be considerable difficulty in the admission of science unless it were either through the instrumentality of the clergy, or by teachers taught in the Catholic University?—Yes. As I have said before, all the principal schools, without exception, are in the hands of the clergy, but all the teachers in them are not necessarily clergymen; and so there would be no difficulty, therefore, in lay teachers, educated in a Catholic University, getting into them, and as a matter of course the clergymen could not help having some such men associated with them.

13,460. What I ventured to suggest was, that you would greatly prefer that they should have been instructed in the Catholic University?—That is the desire of the Catholic bishops and clergy, of the heads of schools, and of the majority of lay Catholics who subscribe to support the University.

13,461. (*Chairman.*) Are the Catholic clergy to any extent educated at the Catholic University?—Not many; some few have been, but not many, because the Faculty of Theology has never been really established, in the full sense of the word, as a teaching faculty.

13,462. But they grant degrees in theology, do they not?—They grant degrees, and some of those on whom they have been conferred have been educated in theology elsewhere, but there are only very few lectures in theology given in the University, the chief reason being that the funds were wanted for the other faculties, and that there was provision made, or believed to be made, in Maynooth, and in the colleges which we have in Paris and in Rome, where there are funds for the purpose. I may also add that a large majority of the clergy being taken from a class who cannot afford to pay for University education could not, therefore, attend the University unless exhibitions were established to help them. This has been a formidable obstacle to our having the Faculty of Theology set up.

13,463. What is your opinion as to the question of how far science can be effectually advanced by a system of examinations?—A system of mere exami-

W. K. Sullivan, Esq., Ph.D.

18 July 1872.

nations would not do anything whatever for the advancement of science. I say that generally, but there are special reasons why in Ireland such a system would be disastrous to education, and would retard instead of promoting science. One of the principal reasons is that the heads of our Catholic intermediate schools are not able to draw the distinction between an University and a school. If you established an examining University instead of a teaching one, these schools would take to grinding their scholars in the subjects of the University course, and they would confound University training and discipline with the training of boys, and you would thus produce a very hotbed state of development among the youth of the country. What Irish Catholics want very much is a real University education, the action of which would be very soon felt in the higher tone of thought which would spring up in them.

13,464. (*Sir J. P. Kay-Shuttleworth.*) Supposing that one of the conditions of the examination by the central examining body was that the student should present a certificate of having gone through a collegiate course before he came up for examination, a large part of the difficulty which you apprehend would, I suppose, be obviated?—I scarcely think you can draw the line of demarcation and say what college is an University College and what one is not. That difficulty presented itself at the time of the Supplemental Charter. We attempted to do that in the Senate of the Queen's University, and the first result of it was, that we had applications from schools of every grade, I would almost say a hedge school, to be placed upon the list.

13,465. But supposing that a central body, such as has been already indicated, having a representative character, existed, which should possess the confidence of political and religious parties in Ireland, might not to that body be confided the duty of indicating what teaching bodies should be associated with it, through which students should necessarily pass before they came for examination?—I do not think you could give them the power of doing that. We attempted to do precisely that in the case of the Senate of the Queen's University. We fixed a standard, and that standard was based upon the subjects taught, and upon the rank of the professors. One college, which I need not name, which begins the education of boys at seven, and certainly does not leave them off in many cases until 20, produced a printed paper and laid it before the Senate with a complete Faculty of Science in every branch of it—physiology, chemistry, and the higher mathematics—the professor of physiology being a local doctor who was occupied about 9 or 10 hours a day in attending fever patients, he being in fact one of the best known physicians in the country. The chemistry was to be done by the head of the college himself, and so for the other subjects. The document, as it came before the Senate of Queen's University, was in such a form that I am quite sure that technically we should have been bound to act upon it if the Supplemental Charter had not legally fallen through.

13,466. That is to say, if you accepted the proficiency of persons applying without further examination?—Quite so; but I think you would find it very difficult when you go to a college to say that a particular man would be unable to teach a particular subject. A mere hasty visit would not determine it.

13,467. But it would be very easy to determine whether a doctor who was working nine hours a day could also give lessons in physiology or chemistry?—Those details would hardly be performed by a body composed of a board of gentlemen meeting together for a few hours. I have had experience of the manner in which those things are done, and I can tell you that they will not do it. Take the medical schools of Dublin, which are supposed to be visited by the College of Surgeons who license them. The Dublin College of Surgeons is supposed to examine the condition of the medical schools, but after a long connexion with two medical schools I can say that I never remember either of them being visited by the College of Surgeons, or their means of teaching any of the subjects of the medical course looked into.

13,468. Are the members of the Council of the Queen's University paid for the discharge of their duties?—No.

13,469. But supposing that such a representative council as I have alluded to were adequately remunerated for the efficient discharge of those duties, would not some of those difficulties vanish?—I quite admit that. If it became their duty, almost their sole duty, I daresay they would do it if they were properly paid.

13,470. In that case it would not be difficult to define through what teaching institutions students should pass before they came up for examination by a central representative council, and in that case would not many of your objections be removed?—If they did the work efficiently, and really looked into the means which any college did possess of teaching the subjects that were put upon their programme, and further had the means of testing the acquirements of students after they had gone through the course, I admit that a good many of my objections would be removed.

13,471. In looking at the very great political difficulties that must be encountered in Ireland in a just distribution of the means of high education in that country, it would be worth while, would it not, to pay for efficient services from such a central representative body?—I suppose it would.

13,472. (*Professor Huxley.*) Can you inform the Commission whether there is any obstacle in the way of students in the Catholic University obtaining degrees from the Queen's University?—Yes. No student of the Catholic University in any faculty except medicine can get a degree in the Queen's University. The Queen's Colleges require in the Faculty of Arts, which is the equivalent of our two faculties of Philosophy and Letters and of Science, and in that of Law and in the Engineering School, attendance at the lectures given in those faculties in some one of the Queen's Colleges for the whole period of the undergraduate course. But the larger number of students of the Queen's University are medical students, the number of arts students being very limited indeed. For instance, the total number of Catholics in the other faculties only amount to a little over 30, whereas a very considerable number of Catholic medical students have got degrees in the Queen's University. The medical students are allowed to go up for their degree after one session's attendance. That session commences in October and ends in May, or the beginning of June. When the session closes, the professors come up and examine in Dublin, and for that one session of six months a medical student can become an M.D. of the Queen's University. A large number of medical students have made their medical studies partly in Dublin and partly in one of the Queen's Colleges, and some have never attended more than the one session in a Queen's College.

13,473. But students of the Catholic University in medicine are not required, are they, to attend in one of the Queen's Colleges before they graduate in the Queen's University?—Yes. Any student whatever who presents himself for a degree in medicine in the Queen's University must give evidence that he has attended at least one session in a Queen's College; but in the other faculties six months will not be sufficient; he must attend the whole course, whatever it is.

13,474. There is no Queen's College in Dublin, is there?—No.

13,475. Then, as a matter of fact, are all the Dublin medical students excluded from taking a degree in the Queen's University unless they go either to Belfast, or Cork, or Galway?—Yes, certainly.

13,476. You stated, did you not, that there are a great number of medical students at the Catholic University?—Yes.

13,477. Where do they go to to obtain degrees?—The majority do not get a degree at all, they get a license from one of the Colleges of Surgeons or Physicians. Those who wish to have a degree go to the

W. K. Sullivan, Esq., Ph.D.

18 July 1872.

Queen's University; for this purpose they have to go to Galway, Cork, or Belfast, and attend two lectures in arts, one lecture being generally French and the other natural philosophy, and they attend two courses in medicine, which are generally the subjects that they require for that particular period of their course. If they go at the beginning of their medical studies they will take out chemistry, and if they go at a later period they will probably take out medical jurisprudence and materia medica.

13,478. (*Professor Smith.*) There is no way whatever in which one of your medical students can obtain a medical degree in Ireland without going to some other institution?—No, no way whatever. The only University really open to our students is the University of London.

13,479. (*Sir J. P. Kay-Shuttleworth.*) Practically, have many students of the Catholic University taken their degrees at the London University?—I think in the whole period, from 1856 to the present, so far as I know, only one. More recently another student intended to take a degree in the London University, but he relinquished it and went into one of the Queen's Colleges; and the reason I think why he selected the London University in the first instance was, that he held an exhibition in one of the colonies, and therefore wished to carry back a degree that was well recognised and known there. I may add that the one student who did graduate in the London University held a similar scholarship in the same colony. The second student of whom I spoke has obtained his degree in the Queen's University.

13,480. (*Chairman.*) Is there any other point upon which you could give the Commission information which might be useful to them?—With reference to what Dr. Lyons has stated as to the margin which exists in the country for University students, it is intimately connected with the question that I have raised with regard to the position of the intermediate schools, which at present perform, very badly, the functions, as I have endeavoured to explain, of University colleges; and if we had statistics of any of those institutions we should find that like the one which I gave as an example, without naming it, they educate boys from the age of 7 to 20 or 21; so that a considerable number of the middle and upper classes of Catholics in Ireland do not go at all to any University; yet they are able to pay a large premium of 50*l.* or 60*l.* or more in those schools, and they frequently remain in them till the age of 20 or 21, fully three years after the time when they ought to have been at an University.

The witness withdrew.

H. Hennessy, Esq., F.R.S.

HENRY HENNESSY, Esq., F.R.S., examined.

13,481. (*Chairman.*) What is the office which you hold in the Catholic University of Ireland?—Professor of Natural Philosophy.

13,482. You are also, I believe, Vice-President of the Royal Irish Academy?—Yes.

13,483. And fellow of the Royal Society?—Yes.

13,484. What are your duties in connection with your professorship in the University?—They are to deliver lectures upon every department of natural philosophy, such as mechanics, heat, light, electricity, sound, and meteorology, and to hold examinations at stated intervals; some of those examinations are intended for tutorial purposes, for testing the students during their progress and pointing out their deficiencies; others are systematic, at the end of each term and also at the end of the session, and those being more of a formal and official character, the results are usually communicated to the head of the University.

13,485. Have you the students in several years of their course of instruction?—At first we had two years' students and one year's students, but the students of a higher class, those who would constitute two years' students, have fallen off very much, and, in fact, practically, that class of students no longer requires to be separated into a regular class.

13,486. Are your students chiefly of the second or third year in the University?—Both in the second and third year.

13,487. You do not take them in the first year?—No.

13,488. What appliances have you for illustrating your lectures?—There are apparatus for illustrating mechanics, hydrostatics, hydraulics, acoustics, optics, electricity, and heat. Those apparatus were obtained principally in Paris not long after the time the University was first opened, or about the time that I entered upon my duties, which was in the year 1856. Since then very few additions have been made to the apparatus, but I believe at the time they were got they were the best of their kind. They were got from one of the best makers in Paris. I should mention that partly in consequence of the greater part of my apparatus having been got in Paris, and from other grounds, and especially for facilitating problems involving numerical calculations, I have usually in my lectures employed the metrical system of weights and measures, and also used the centigrade thermometer in connection with heat.

13,489. I suppose if you had the means you would think it very desirable that you should be provided with additional appliances?—Yes, I think it is most desirable. There are many departments of experimental inquiry which are very imperfectly illustrated in the cabinet.

13,490. Have you plenty of space?—Ample for the present requirements of the department, but not quite sufficient to provide for the supplementary apparatus required to complete the collection. The physical cabinet of the University is a very large and handsome room. It might be interesting to you to know that it was in that very room His Royal Highness the Prince of Wales received the University, at the time he did it the honour of visiting it.

13,491. Would you wish to make any statement with regard to the books which you recommend to the students?—The books which have been principally recommended to students by me, more for the higher class students, in experimental physics are "Pouillet's Elemens de Physique." I introduced at the outset, before the book was well known in this country, "Ganôt's Traité de Physique," a small elementary treatise, which was afterwards adopted in the Queen's University, and also in Trinity College, subsequent to my introduction of it; and at present one book which I most usually recommend is "Deschanel's Physics," edited by Professor Everett, of Queen's College, Belfast.

13,492. I think you have already stated that the students who apply themselves to the higher portions of mathematical or physical science are but few in number; can you assign any special reason for this circumstance?—I shall endeavour to do so. In Ireland a career in science is extremely restricted for Roman Catholics. The very Act by which Roman Catholics were relieved, in 1829, from disabilities which excluded them from Parliament, the bench, and high offices of the State, formally maintains their continued exclusion from offices connected with Universities and Colleges. Until of late years, there were comparatively no positions to which Roman Catholics could aspire in connexion with mathematical or physical science. The best positions in Ireland, namely, the fellowships and professorships of the University of Dublin, are absolutely held only by members of the late Established Church in Ireland. Also, according to the regulation connected with the College of Maynooth, the only scientific professorship there is conferred only upon clergymen, therefore Catholic laymen in general are excluded from it. And, lastly, in connexion with the Queen's Colleges, from some cause which I cannot well point out, no Roman Catholic is usually appointed to any Chair of a scientific nature there unless he has

H. Hennessy, Esq., F.R.S.

18 July 1872.

considerable political influence; and I might allude, in point of fact, to one case which lately came under my notice, that of Mr. Casey, who is an eminent mathematician, and from whom a paper appears in the last part of the "Philosophical Transactions," and he had also previously published other valuable papers. I understood that a man of his standing among the Catholic body could not be appointed to a Chair in the Queen's Colleges, and one of the reasons assigned, as I understood, was one which, if seriously maintained, I would take the opportunity of calling the attention of the Commission to, namely, that his age was too advanced; yet he is a man comparatively in the prime of life. I wish to dwell upon that, because it appears to me unjust towards science to apply to it the same hard-and-fast line as would be applied to a junior position in the Civil Service; I would respectfully submit to the Commission that a man of science who has been cultivating science for many years is practically in the Civil Service of the country already. He is practically performing work which gives him that experience which ought to count for years in the Civil Service. Therefore, for any appointments in science I should think it injudicious to apply that hard-and-fast line which might be applied for junior appointments in the Civil Service. I do not know precisely Mr. Casey's age, but I think it was probably between 40 and 50; it cannot exceed 50, I should think.

13,493. (*Professor Huxley.*) Has the objection appeared publicly?—I have it on his own authority, and I have had a concurring statement made to me by an eminent officer of the Queen's University, which shows that the objection was a general objection of that nature.

13,494. (*Chairman.*) Do you consider that the principal reason why so few of your students apply themselves to the higher portions of mathematical or physical science is, that there is no future career open to them?—Yes, I do, because, for the successful study of science, it requires that a man should have almost no other occupation. It is very difficult for a man who is occupied with professional labours also to prosecute original studies in science, or to devote himself even with great energy to teaching science, or to its cultivation in any form, whether for its advancement or for its diffusion; and, therefore, it appears to me that the great majority of those who successfully cultivate science are either men of independent means themselves or who obtain some public position which is directly connected with the study of science itself, and unless men have such positions open to them, of course it prevents them from cultivating such subjects.

13,495. Have any of your students obtained appointments in England; for instance, in any of the Catholic colleges of England?—I recollect that some students, who were formerly in the University, did get appointments as teachers in some of the Catholic colleges in England.

13,496. Have any attempts been made in the University at laying down a course of study and examination for the degree of bachelor of science?—Yes. Several years ago a programme was drawn up of studies for the degree of bachelor of science, which I might indicate as contained in the calendar, and an outline of various studies, chiefly including mathematical and physical science, was laid down, and this idea was entertained, and I believe the programme was first drawn up even before the idea had been promulgated in the London University; a similar idea has existed in the Catholic University.

13,497. Was it contemplated that the Catholic University should grant a degree of bachelor of science, even if it did not grant other degrees?—It was, but ultimately the whole subject of degrees became so complicated with other considerations that it was practically not carried out, or in a very slight degree.

13,498. The University considers that it has a ground of complaint that it is not permitted to grant degrees?—Yes.

13,499. Do you wish to make any remarks upon that subject?—I do. I consider that people in Ireland generally know very little about the nature of an University. They always attach to the idea of an University a body which has the power of granting degrees, and, therefore, although education may be given in an University, unless it has that power, people will not have, as it were, a trust in it. They have the same sort of feeling about it (if I might use the illustration) that people would have in purchasing silver plate which had not been properly hall marked, although they might believe it to be silver, still they would have an unpleasant feeling about it. That is the kind of sensation which I believe prevails in the public mind on the question, and, therefore, students, no matter how well informed, would feel themselves placed at a disadvantage, unless they are so marked, as to immediately have their attainments command some weight.

13,500. What is your opinion as to the effect which a mere degree-giving body would have upon the study of science?—I think it would be injurious, and for these reasons: at present, owing to the undue value attached to the mere mark of knowledge as compared to knowledge itself, any movement of the State in that direction would tend to increase that unhealthy condition of the public mind, and unless it were accompanied by great development in the teaching power, and the appliances required for teaching, and for diffusing knowledge, I think in that way it would be hurtful; again, it would tend certainly very much to prevent the formation of a great Catholic University in the sense of the one that we have been endeavouring to form; and it would tend to leave education much more in the hands of the schools than it even now is. A great many of those schools would be content with preparing their best students, and getting them crammed for the purpose of passing an examination, instead of allowing them to pass through a systematic course of study and attendance at lectures at the University; and another effect that it would have, and which may be inferred from the evidence already given, would be this, most of the schools in Ireland are conducted by clergymen, and in many cases some of the best are conducted by members of the religious orders, and the result of such an examining board would be that the education would be still more clerical than even at present; it would be more in their hands than it has been hitherto, and it would be more permanently placed in their hands. I do not mean to say that that is any defect in it, but it would certainly have that result, and although I believe that it has in many respects been attended with great benefit to the young students, it remains to be considered whether it be quite advisable for the students of an advanced position.

13,501. I understand that the professors of the Catholic University are enjoined by the statutes to promote science through the press; do you refer on this subject to "The Atlantis," of which we have already heard?—Yes, I partly refer to "The Atlantis," and also to the fact that I have contributed papers to scientific publications, and have taken some part in the proceedings of the British Association, the Royal Society, the Royal Irish Academy, and other bodies.

13,502. Have some of the other professors, in a similar manner, done something towards the promotion of science?—Yes, I believe that every professor in the Faculty of Science has more or less contributed something towards the promotion of science in his department.

13,503. Are they specifically enjoined by the statutes of the University to make exertions in that direction?—Yes, they are specifically enjoined to do so.

13,504. Have you any assistance in the delivery of your lectures?—No, I have no assistance.

13,505. Is any professor supplied with demonstrators or assistants of any kind?—Not in the Faculty of Science.

13,506. (*Chairman.*) Have you anything further which you would wish to add to your evidence?—

H. Hennessy, Esq., F.R.S.

18 July 1872.

There were two points which I should like to mention. One of them was a point in Dr. Lyons' evidence, where he alluded to circumstances about the religious bearing of the University. I should mention for the information of the Commission that no stringent profession of faith has ever been required of any of the professors except those of theology. The only professors who have ever been required to make any solemn profession of faith are the professors of theology, but in no other department whatever. I should also mention, with regard to the publications of the University, that I have been informed, and, indeed, I have witnessed it myself at the public sales in Dublin, that the old numbers of "The Atlantis" are selling at an enhanced price over the publication price. [In conclusion the witness handed in, for the use of the Commission, copies of a *Discourse on the Study of Science* which he delivered at the Inauguration of the Faculty of Science in the Catholic University. He also referred especially to a passage in support of his views against cramming for examinations, pp. 7–20. *See* APPENDIX VI.]

The witness withdrew.

Adjourned.

No. 6, Old Palace Yard, Westminster, Wednesday, 13th November 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., LL.D., F.R.S.

The Earl of Derby, F.R.S.

13 Nov. 1872.

The Right Hon. EDWARD HENRY SMITH-STANLEY, EARL OF DERBY, F.R.S., examined.

13,507. (*Chairman.*) I believe your Lordship has been so good as to consider certain proposals which have been laid before the Commission by some of the witnesses whom we have examined, bearing on the relations of the State to science?—I have seen various suggestions which have been laid before the Commission.

13,508. Will you have the kindness to inform us whether, in your opinion, it is the duty of the State to aid the higher teaching of science; whether, for instance, it would be a legitimate application of the public money for the State to aid such colleges as Owens College and other suggested colleges of the same kind, or the Scotch Universities, or such colleges as University College and King's College?—It is more easy to speak upon the general principle than to apply that principle to particular cases. With regard to the general principle, whether it is or is not the duty of the State to assist in the higher teaching of science, I conceive that that is a function which the State may, if Parliament think fit, very properly, and without any public injury, undertake. I should set out from this assumption, that we ought to be extremely cautious in increasing the burdens, and in multiplying the functions of the State, first of all because of the inconvenience of an increase of taxation, and next because of the danger of that large class of abuses which may arise wherever central funds are distributed amongst various localities. In the particular case to which your Grace's question refers, that is to say, the assistance given to scientific teaching, I presume that the increase to the public burdens is not a matter which would require to be very much considered. The total amount to be dealt with would probably be altogether insignificant in comparison with the resources of this country. The other danger is a more serious one, namely, the danger of increasing public patronage and of multiplying those abuses which seem to be more or less inseparably connected with it. I think that assistance given to the teaching of science is more justifiable than almost any similar demand which can be made upon the State, because, in the first place, the advantage gained by the increase of scientific education is absolutely undisputed and indisputable; and, in the next place, because, from the nature of the case, the number of persons who will actively interest themselves in the promotion of science is probably not very considerable, and, therefore, you have less of private and individual effort to rely upon than in the case of most useful public works. What I mean, putting it generally, is this: that the motives which will induce individuals to build and endow a hospital, or a church, or a charitable asylum, or even a school for ordinary popular teaching, do not apply with the same force, as regards the great majority of mankind, where scientific teaching is concerned. There must be much more of it than we have had as yet, before there can be any general appreciation of it in the public mind. I think, therefore, that you are free in this case from the objection which always has to be considered where State aid is demanded, namely, that by the State taking upon itself a duty which individuals would otherwise perform, you are checking private enterprise, and possibly, after all, you are providing smaller funds for the object which you have in view, than those which private liberality, unassisted by the State, would supply. I may, perhaps, add, that I think if you can reason at all upon these matters in a general and theoretical manner, that the principle of aid to scientific teaching was conceded when assistance was first granted by the State to such an institution as the British Museum. I do not suppose that the British Museum was endowed and supported by the State merely as a place of popular amusement, but as an institution which would be valuable in the promotion, amongst other things, of scientific culture. The same argument would apply to the assistance, although I believe it is small in amount, which has been given to the Royal Society, and which I believe is given in the way of providing accommodation to other scientific bodies.

13,509. Besides giving assistance to such bodies as the British Museum, do you think it is a legitimate application of the public money to appropriate any of it to teaching institutions of the nature of colleges; for instance, in giving them money for erecting buildings or for endowing professorships?—That seems to me a very large question to be answered by yes or no. It involves very numerous considerations of various kinds, and I am afraid that I shall hardly do justice to all of them. But I would say generally that before you come upon the treasury for additional endowments for scientific purposes, I think Parliament and the public may reasonably expect you to show that the utmost use has been made of the endowments which already exist.

13,510. Your Lordship is probably aware that 120,000*l.* was granted by the Government a few years ago to the Glasgow University for buildings, and the Commission have had evidence from some of the other

The Earl of Derby, F.R.S.

13 Nov. 1872.

Scotch Universities that they are hampered by the want of adequate buildings, and the example of Glasgow has rather encouraged them to look to the Government for assistance; have you formed any opinion upon that subject?—If any general plan of assistance to local scientific bodies is proposed, I think it would be a matter of extreme importance that it should be subject to some fixed general rule. I cannot conceive of anything more inconvenient, or in a certain sense more dangerous, than to encourage any town or any district to make application to the State for a grant, and the amount of that grant, and the question whether it shall be given or withheld being left entirely dependent upon the pleasure of the executive of the day, or of the executive of the day, controlled by Parliament. In the first place, under such a system, of what I would call merely optional assistance, you would inevitably have, without ascribing blame to any body, great fluctuation and great uncertainty. In one year the means may be abundant and Parliament and the public may be disposed to take a liberal view, whereas two or three years later there may be some difficulty in producing a satisfactory budget, and it may become the object of the minister, and Parliament may sympathize with him in it, to cut down expense as far as possible. Under those circumstances, without attributing blame to any one, but merely in consequence of the fluctuation of opinion, from time to time, in a popular body, you would have the request of A. granted, and the request of B. under precisely similar circumstances refused. It is not necessary, I think, to argue as to the inconvenience of such a state of things. In the next place, where so many local interests are concerned, you would have, perhaps, the reality, but certainly the suspicion, of the decision in each case being influenced by political partiality.

13,511. Would it be a matter of great difficulty, do you think, to lay down any general principle which would be applicable to all such cases?—I think that the first and most indispensable principle is, if you are assisting local institutions, to make your assistance more or less dependent upon the amount of local contribution. In that way, instead of discouraging, you stimulate private zeal and private enterprize; whereas, if you go on the principle of giving without asking for any local contribution in return, obviously no one will come forward and aid the object out of their private means, because no one is willing, as a general rule, to pay out of his private means for that which he conceives, if he does not so pay for it, will be paid for at the public expense. On the other hand, it is fair to say, with regard to the principle which I have laid down, that it is liable to this objection, that the poorest localities, which may be those which most require assistance, will, under a system of State assistance proportioned to local grants, obtain it least. That, however, applies in a smaller degree to the question which we are now considering than it does to the question of popular education. If I may recapitulate, the two principles which I would lay down would be these: that in any assistance given towards the teaching of science in any locality by the State, you are to consider, first, whether by so doing you can stimulate instead of check private liberality; and you are to consider, in the next place, before you come upon the public for new endowments, whether there are any endowments actually in existence which may be applied to the purpose in question.

13,512. You have spoken of the British Museum and certain other institutions more or less assisted by the Government, and some of the witnesses who have come before us have recommended the establishment of several new institutions, such as additional observatories and laboratories; do you see any objection in principle to the State establishing such institutions provided that a strong case is made out of the advanvantage that would result from them?—I think that the support of an observatory is one of those charges for which the assistance of the State may most fairly be asked, because the expense of maintaining it on a large scale is beyond the means of any individual, and the work done, although of extreme importance, is not of that popular character which would make it easy or would probably make it possible for any sufficient amount of contributions to be derived from the public. I think, therefore, that an observatory may be very fairly supported by the State, as, in point of fact, is the case at present, and if you concede that principle I think that it is a mere matter of detail whether the work to be done in the observatory should be done in one building or in two. I do not think, where an observatory is concerned, that you ought to look at the question of local situation at all. The work that is done is not done for the particular benefit of Greenwich or Edinburgh, or for the place where the observatory is situated, but for the benefit of society in general.

13,513. I think there has been a very general consent amongst a large number of men of science who have been examined before this Commission that in the present state of science there are many branches as to which there is no probability of their being advanced to the degree to which they are capable of being advanced by private effort, and without the assistance of State funds in some shape; what is your Lordship's opinion upon that subject?—I am, as a general rule, very strongly in favour of private effort and very decidedly against the application of State funds to any purpose that can be accomplished without them; but I think that if there is any exception to that which I venture to call a sound and wholesome rule, it is in the case of scientific research, because the results are not immediate, they are not popular in their character, and they bring absolutely no pecuniary advantage to the person engaged in working them out. A great mathematical or a great astronomical discovery is a benefit to the whole community, and in a certain sense to mankind in general; but it is productive of absolutely no benefit, in a pecuniary point of view, to the person who has given his labour to it.

13,514. Turning to another branch of the inquiry, it appears that in many departments of the State the Government require advice for their own purposes, for carrying on the duties that are entrusted to them by Parliament, and the evidence that has been given to us appears to show that matters are not in a very satisfactory state as respects the obtaining of that advice, and that it is rather a matter of haphazard how they get their advice on subjects upon which it is required; have you any opinion upon that subject with which you could favour the Commission?—I should like to be more satisfied than I am at present as to the reality of the grievance before I undertook to propose any remedy. I do not, as at present advised, see what the difficulty is of obtaining the best scientific assistance when any Government department chooses to call for it. As a matter of fact the names of the most eminent men in every department of science are perfectly well known, and they have always, as far as I am aware, been very creditably ready to give their assistance when it has been asked for; and I should be inclined to think that if there are cases where a Government department has not had the benefit of that assistance it has rather been because it was not asked for in time than because there was any difficulty in obtaining it.

13,515. Many of the witnesses have strongly urged the appointment of a Scientific Council to advise the Government in all matters in which the connection between science and the State is involved: some have recommended a very elaborate organization, and some have recommended a scheme of a much less ambitious character; do you consider that anything of the kind is required?—In considering a proposition of that kind, which is practically a new one, it is obvious that the objections to it are apt to occur to one in the first instance, and I speak therefore under considerable reserve. But, as at present advised, I am very sceptical either as to the necessity, or as to the utility, or as to the successful working of such a

The Earl of Derby, F.R.S.

13 Nov. 1872.

council as I have seen proposed. One objection to it is that if matters for which the head of a department is responsible are to be referred to the council, and if upon those matters the council is to pronounce an authoritative opinion, you will very materially lessen the responsibility of the one person who ought to be responsible to Parliament. I may take an instance: I have seen it stated in some of the evidence which has been given before the Commission that if the Admiralty had had proper advice as to the construction of ships, a great disaster which is fresh in all our memories would not have occurred. It seems to me impossible to suppose that you would get any competent person to advise the Admiralty in the matter of ship-building if he were to be under two masters, that is to say, if his plans were to go, on the one hand, to a scientific council to be approved by them, they having nothing to do with the question of expense, and, on the other hand, to go to the head of that department and to Parliament to be approved again by those two parties, they having nothing to do with the science of the matter, but looking principally to the expense. I think that that would entirely destroy the responsibility of the executive officer, and would destroy that independence which he ought to have in the performance of his functions. If you want scientific advice in a matter of that kind I would place it in the department rather than outside, or, which is practically the same thing, I would refer the specific question upon which the opinion is wanted to one or more of those persons who could bring the highest scientific authority and ability to bear upon it. It strikes me further that if you are to have a council including all the departments of science, and if that council is to pronounce its opinion collectively upon all matters submitted to it, you will in fact have every question decided by a great majority of persons who, however eminent in their own department of science, know very little of the particular matter in question.

13,516. As the tendency of your Lordship's opinion is certainly unfavourable to the establishment of such a council, it seems hardly necessary to ask your opinion as to its constitution?—I should like to know, in the first place, what is the work which such a body as is proposed is expected to do.

13,517. One function would probably be to advise the State as to the application of money for the higher teaching of science and for scientific research, and also to advise the Government with respect to any applications that may come before it for grants of money connected with science?—It seems to me that that is a matter which falls strictly within the province of the Minister of Education.

13,518. There are many cases at present in which it is stated that applicants find a great difficulty in knowing to which department of the State they ought to apply, and that there does not seem to be, with reference to many subjects, any particular department of the Government that has the power of dealing with them, and the applicants are referred from one department to another; would not that complaint be met if such a council were established?—I am very far from contending that our administrative organization is perfect, but, according to my very limited experience, whenever there is a complaint that a subject has been transferred from one department to another, it often happens that what is really meant is merely this, that not one but two or more departments are equally concerned in it, and, therefore, the opinion of all of them must be expressed before a decision can be taken.

13,519. (*Professor Huxley.*) The mode of seeking advice which at present obtains is, that the minister, judging by general report of the distinction of a given man in any particular branch of science, consults him of his own motion upon the question upon which he seeks advice; has your Lordship ever reflected upon the difficulty to which that gives rise? For example, it may be said that Mr. A., who is consulted, is not the best man; or he may be a person who is in controversial relations with the scientific adviser of the department: might not many difficulties of this kind, which it has been suggested would arise, be obviated by the existence of a scientific council?—No doubt, if one man is selected as the general adviser of some particular department of the Government upon a matter of science, it is not improbable that there may be some jealousy in the minds of certain other people who think that they could give quite as good advice, or possibly better; but it seems to me that unless the proposed council is to be unlimited in number, precisely the same difficulty will arise under that system. There will be a large number of persons outside it who will think that they have a better claim to be in it than those who actually are there; and precisely the same feeling of jealousy would then exist, and would produce the same amount of inconvenience.

13,520. It has been suggested that the council being a public body, and its proceedings being public, they would act under a sense of responsibility which an adviser whom the minister consults privately does not feel; has your Lordship formed any opinion upon that subject?—Before I can answer that question I must know, more precisely than I do, in what form it is proposed that the council which is spoken of should give its advice, because I have seen various plans put forward before this Commission, and I do not know which of them we are discussing.

13,521. What I referred to was the suggestion that the council should be a body the proceedings of which should be public, and which should, therefore, live, as it were, under the control of public opinion. The present objection is that any advice which is sought by the Government is given privately by some person who, whatever his eminence, is not responsible, and it is imagined that a council the proceedings of which would be public would be under the check of public opinion and would be free from this objection?—You may be quite sure that any minister who wants an opinion upon a scientific matter will try and get the very best opinion that he can. He has no possible interest in doing otherwise; on the contrary, he has the greatest possible interest in doing that. And, on the whole, I think that a man in that position, with what I may call an unlimited command of assistance and advice, is quite as likely to make a good selection as any one else could do for him.

13,522. (*Chairman.*) The only existing institution that could be at all compared to the proposed council is the Indian Council; have you formed any opinion as to whether that works well or not?—It is a long while since I was at the head of Indian affairs, but, as far as I can judge, I believe that it does work well. But I do not admit the analogy between the two cases. The business which is referred to the Secretary of State for India is that of revising all the ordinary administrative work of the Indian Empire. It is a very fair matter of argument whether more of that is not sent home than is necessary, but an enormous number of questions of Indian administration come in the course of every year before the Indian minister, and the justification for the existence of the Indian Council is this, that if the minister were not advised by men in that position he would be advised by clerks. It is simply impossible, merely from the amount of business brought before him, and also from his previous unfamiliarity with it, that he should decide upon his own unassisted judgment many of the questions which come before him. Moreover, there was another reason for creating the Indian Council which has no application to such a body as is now proposed. It must be remembered that the Indian minister, checked only by his Council, has the absolute right of administering the whole Indian revenue which now amounts to something like 50,000,000*l.*; a revenue which is not voted in Parliament; and even if it were voted in Parliament the vote would be a mere form, because Parliament would naturally be quite indifferent to an expenditure which did not fall upon its own constituents. You may take it that practically the House of Commons does not interest itself, and it never has interested itself in the control of the Indian

The Earl of Derby, F.R.S.

13 Nov. 1872.

finances; and, therefore, the existence of a partly independent body like the Indian Council is the only check, it may be a feeble check, but it is the only check upon the absolute and unlimited power of the Secretary of State for India for the time being over the whole Indian revenue. That is a state of things to which there is no parallel in the case which is now being put before me.

13,523. (*Professor Huxley.*) In the case of an observatory, as you are aware, there is a definite line of work laid down for the persons who are employed in it; but proposals have been brought before this Commission to establish physical laboratories and chemical laboratories at the expense of the State, in which a number of investigators might carry on their researches, not on any definite line laid down, but on whatever line suggested itself to them; would you think that such a course would be a desirable one?—I do not think that my opinion would be of much value upon a point of that kind. The difficulty which occurs to me is, what security have you for obtaining any results? I think that, in one way or another, where you have a man of very great eminence as a scientific discoverer, it is unquestionably the duty of the State to provide him with means and leisure to carry on his work. Whether that is to be done by giving him an office under the British Museum, or in any similar institution, or whether it is to be done by simply granting him a pension in recognition of eminent scientific service, or in whatever other way it is done, it seems to me to be immaterial, but I certainly consider that it is a very important part of the public duty to relieve men who have shown an eminent capacity for original discovery and research from the necessity of engaging in a lower kind of work as a means of livelihood. And I may mention, in passing, that amongst the objections which I take to the creation of such a council as is proposed would be this, that if you did not include in it the most eminent scientific men of the time it would obviously fail of its purpose; and if you did include in it the most eminent scientific men of the time I think that they would be applying to an inferior class of work a great deal of time and ability which might be better employed.

13,524. (*Chairman.*) A suggestion was made by certain witnesses, with respect to laboratories, that, without going so far as establishing State laboratories, a great deal of good might be done by the State assisting laboratories connected with colleges, and calling upon those connected with those institutions to allow private investigators to make use of the laboratories for research, and the State receiving, to this extent, a return for its money; do you concur in that view?—I do not quite understand whether your Grace is speaking of laboratories for the purpose of teaching what is already known, or for original research.

13,525. Mainly for teaching what is already known; but strong opinions have been expressed that it is very desirable that laboratories mainly intended for teaching should not exclude original research, that the professors and teachers who have charge of those laboratories should, besides teaching, to a certain extent, occupy themselves with original research, and that in return for any aid from the Government, private investigators might, under certain conditions, be allowed to make use of those laboratories?—It seems to me that that question resolves itself into the larger question of the general assistance to be given to scientific teaching at colleges or other institutions. If you assist a college liberally, whatever it may be, I think you may assume that it will provide for itself a laboratory as it provides all other necessary appliances of teaching.

13,526. (*Professor Stokes.*) When a particular department has occasion, we will say, to institute a series of experiments involving scientific research bearing on that particular department, and in other instances of a similar kind, might there not be some advantage if the proposed plan of experiment prepared by the scientific authorities of that department should be submitted to a body of scientific men acquainted with other branches of science, because it might be possible that some flaw might be detected, or some simpler mode of accomplishing the object might be pointed out, by means of the knowledge which a scientific man might have who was not specially bound up with that particular department or who was not engaged perhaps in any Government office at all, and thereby possibly needless expenditure of the public money might be saved, while yet the responsibility for proposing the set of experiments or whatever other mode of expenditure might be involved would rest upon the person connected with the department who had made the proposal?—I think that in any case where it is desirable that a course of scientific experiments should be carried on under the authority of a Government department it would be a very great mistake to make it a rule to employ no person in those experiments except those who are connected with the department. In a case of that kind I think it would be the business of the head of the department to get the best advice from outside that he possibly could. I presume that he would do it, as commonly has been done, by means of a commission. It seems to me that at present there is an unlimited facility for doing that, and that you require no new machinery to make it possible.

13,527. (*Professor Huxley.*) There is a grant of 1,000*l.* which is made every year and administered by a Committee of the Royal Society and other gentlemen who are added to it, for the purpose of enabling persons who pursue original researches to follow them out by aiding them with grants of money; has your Lordship ever considered the manner in which that Government Grant Committee is formed, and if so, do you think it is an advisable mode of administering such funds?—I am always desirous to have a fixed rule for the administration of Government money wherever it is possible; but, in the case of a grant for some special scientific purpose, I do not see how you are to apply any self-acting rule, such as that which governs the assistance given to schools or other educational bodies. It will always be in the power of the House of Commons to reject a grant of that kind if they feel disposed. The minister will always have to consider before he proposes a grant of that kind whether it is likely that Parliament will object to it or not, and upon that question, whether he is likely to get his money or not, he is probably a better judge than any outsider can be.

13,528. In this case it has been the practice for many years that 1,000*l.* should be handed over to the Committee for the purpose of distributing it amongst those investigators who desire pecuniary aid, so that I presume there is no doubt about the money being granted every year. But the point upon which I want to ask your opinion is, whether you consider this Government Grant Committee to be a good machinery for administering public money? As you are probably aware, the members of the Committee are all men of science of standing and position, and they constitute a kind of parliament, by whose votes this money is granted; and, as the Council of the Royal Society adds to its own Committee every year a number of persons from outside the Council, it really is a very fair representative body, a body, in fact, representing all the interests of science?—I speak with some diffidence upon a matter of that kind; but, as far as I can judge, I do not see how you can get a better representative body. I believe that the prestige of the Royal Society is very great. I believe that it includes the most eminent names in science; and I certainly have never heard any complaint that the very limited sum which is applied to the purposes which have been mentioned was in any way supposed to be abused or wasted.

13,529. Supposing it were thought desirable to increase the grant, would this already existing machinery be a fit one to administer such increased grant?—I think so. I do not see how you could

The Earl of Derby, F.R.S.

13 Nov. 1872.

strengthen it. What Parliament will always look to is the weight and authority of the persons who advise as to the application for grants, and if they see that those persons are the leading names in their various branches of science, I apprehend that they would be satisfied.

13,530. (*Sir John Lubbock.*) Supposing that the Council of the Royal Society were of opinion that instead of 1,000*l.*, say 5,000*l.* or 10,000*l.* could be advantageously employed in a similar manner; would you be disposed to consider that it would be desirable for Parliament to grant that demand?—That would depend upon what the money was for.

13,531. Say for researches of a similar character to those which have been undertaken in past years?—I am inclined to think that the House of Commons, if I may speak from my recollection of it, would not be inclined to grudge an addition to the votes for that purpose. They are infinitesimal in comparison with the general expenditure of the country, and I never have heard them complained of. I think that the difficulty would be much more likely to be at the Treasury than in the House of Commons.

13,532. (*Sir J.P. Kay-Shuttleworth.*) As your Lordship is probably aware, there is likewise a Meteorological Committee which is connected, as an advising body, with the Board of Trade, and there is also a consultative body connected with the administration of the Royal Observatory at Greenwich, none of which bodies receive any emolument;—supposing that the funds confided to the Royal Society were considerably increased in amount, would it be quite fair to expect, or would it be wise to depend upon the members of that body for that degree of attention, and the devotion of that amount of time which might be required for the accurate administration of those several functions, unless they received some emolument?—I am not aware what amount of time or attention is involved in the present administration of the grant. Undoubtedly there is a limit beyond which it is not desirable to call upon any man to devote his time without paying him, but as we all know an enormous amount of work is done by Committees and Royal Commissions, whose members are unpaid, and I do not at all agree with the theory, although I have heard it stated, that unpaid service is worth just what it costs.

13,533. There are a great many other matters that have been brought before the Commission, such as the government of the British Museum, and the addition to the present functions of the governing body of another function, namely, the distribution of the surplus specimens of the British Museum for the founding of local museums, the devising of measures for the government of those local museums, and the possible application of any public grants for their encouragement; besides which, very important questions have arisen with respect to the government of such institutions as the botanical garden at Kew in its connection with scientific research, and with the development of horticulture and of forest culture; the Commission have also had brought before them questions relating to local scientific education throughout the country, and it has been suggested that an advising council might bring to one centre a great number of these questions, and might, with authority which would not belong to any special department, and with a degree of experience and skill which is not now possessed by any department, govern the whole of these questions. Has your Lordship reflected whether any function of that kind could be properly discharged by such a council?—It seems to me as if that would be making the council in effect the ministry for education.

13,534. What has been suggested in relation to that has been that the Minister of Education should have connected with his department a scientific council of limited extent who should advise him as to the administration of those several questions?—I think it must be remembered that in every case the House of Commons will have to decide what the grant shall be. The minister, though he may have less scientific information than such a council as you propose, would know better than any member of such a council what he has a chance of being able to carry.

13,535. At present, take, for example, the British Museum, the Minister of Education would have no control over the British Museum, he would have no power of appointing any officer, he would have no power of altering the functions of any officer, there is a rule in the British Museum that any specimens which enter it shall not leave it, and there is, therefore, no power of distribution to local museums; and the British Museum does not at present, therefore, excepting as a general place of resort for scientific observation, subserve the general interests of those departments of scientific education which are connected with observation in the country; if the Minister of Education is to have any control over the British Museum for those objects, is it not quite clear that he would need some advice of a scientific council for the development of that particular part of his functions?—The British Museum is the creation of Parliament. The system of Trustees under which it is worked dates from a time at which the private contributions, out of which it arose, bore a much more important proportion than they do now to the amount supplied by the State; but practically what has been supplied from private sources is now insignificant, and the thing lives, you may say, upon its annual grant of about 100,000*l.* a year. Parliament has, therefore, the power, at any moment, of transferring the management of the museum, if it thinks fit, from the present body of Trustees, and placing it, as I believe the South Kensington Museum is, directly under the minister.

13,536. It has been suggested that some such transference should occur, that the government of the British Museum should have a more scientific character, and that the scientific council of advisers as to its government should be immediately under the Minister of Education; on the whole, perhaps, it may be too much to ask your Lordship for an off-hand opinion upon that subject?—I should say that the scientific element required in the management of the museum was supplied by the heads of the departments. With Professor Owen and Dr. Gray acting in that capacity, it can hardly be said that the scientific element is wanting.

13,537. But if those appointments were made with a view to one theory of the British Museum, and it were considered by Parliament desirable that the utility of the British Museum should be greatly extended, so as to subserve, to a very great extent, the objects of local scientific education throughout the country, might it not be desirable that some change should take place in its management?—If it were desired by Parliament that the British Museum should be taken from its present administrators and placed directly under the Minister, then I presume that it would be managed in the same way as South Kensington is, that is to say, you would have one or more persons of scientific eminence and of practical ability who would be responsible to the Minister for the management of the museum, and the Minister would be responsible to Parliament. I do not see the advantage of employing so cumbrous a machinery as a council.

13,538. Taking the case of the British Museum as an illustration, if the Minister of Education came to be regarded in this country as the Minister responsible to Parliament for the administration of funds and for the right regulation of endowments which have any connection with scientific instruction or the scientific progress of the country, would it not be desirable, in that case, that he should have a permanent council of very eminent men to advise him in the discharge of those functions?—You are speaking of a state of things which does not at present exist, and which, if it is to be brought into existence, would involve, as I assume, the placing of the direction of the great universities of the country under the Minister.

13,539. Not necessarily so. But there might be a great number of provincial institutions which received

The Earl of Derby, F.R.S.

13 Nov. 1872.

grants from the Government on conditions such as have been already alluded to to-day, some of them connected with secondary education, and some connected with higher education, that is, connected with purely scientific education, and it might be desirable, might it not, that there should exist in this country some controlling power to enable the Government to secure the fulfilment of the conditions on which the grants of Parliament were made, as well as for the general development of scientific instruction?—I can only answer that generally, by saying that I am not fond of councils. The case of India was a very peculiar one; and, moreover, it had to be considered, with regard to that, that we were not in fact creating a council, we were rather continuing in a new, and, as we thought, improved form, a council which already existed. We were not creating a new machinery, we were simply applying to a new use some machinery which we found ready to our hands, and with which it would have been exceedingly difficult to dispense. But, speaking generally, I doubt whether the machinery of an administrative council is a desirable one. The members of a council, perhaps, do not bring quite the amount of energy and interest to bear upon the consideration of questions that they would if they were singly and individually to be responsible for the decision come to. On the other hand, the Minister who is the head of the council, feels his responsibility diminished when he can shield himself under their authority. Then there is also the risk of awkward complications. If your council is inclined to pull one way and Parliament is pulling the other, the Minister will, in the long run, do what Parliament wishes him to do.

13,540. (*Chairman.*) Amongst the reasons that have been assigned by some of the witnesses for the establishment of a council, I think one holds rather a prominent place, and that is, the alleged uncertainty of Government action in respect of questions relating to science. For instance, the President of the Geographical Society states that, in his opinion, pecuniary assistance is sometimes granted and sometimes withheld under precisely similar conditions. Do you not think it would be desirable, if possible, that some system should be adopted by which greater uniformity in the decisions on such questions would be attained?—In the particular case referred to, if it were thought that the Government ought to do more than it does for the promotion of geographical discovery, I think the obvious course would be to put a certain sum yearly into the hands of the Geographical Society. So long as that is not done there will always be complaints of the kind which your Grace has mentioned, of a request being at one time granted and at another time refused under conditions which appear to the applicants exactly similar. I should be prepared to contend that it was not in itself unreasonable, but it might be quite a right thing in a time of great pressure upon the finances to cut down everything that may be called optional expenditure as far as possible; and it might be quite legitimate to grant 4,000*l.* or 5,000*l.* for exploration in Africa at a time when the finances of the country were prosperous, and to withhold a similar grant at a time when the nation was economizing to the utmost.

13,541. Probably the witnesses would have admitted the force of that argument, but I think the statement is, that, under apparently precisely similar circumstances, there is a great deal of uncertainty as to whether the recommendations will receive attention or not?—That pervades the whole of our administrative system; and it is, I am afraid, an inevitable condition of living under a popular government.

13,542. (*Sir John Lubbock.*) I do not quite gather from your Lordship whether you consider the existing mode of government of the British Museum by Trustees, of whom, I believe, only two or at most three are men of science, and who are represented in Parliament by one of that number, to be a good system of government?—Perhaps I am not an impartial judge. I am a Trustee, but I consider that we hold our offices simply by the desire of Parliament, and of course we are ready to resign them if a better arrangement could be made.

13,543. I do not wish to imply that all the Trustees should be men particularly devoted to special branches of science, but only to ask whether the number of scientific men amongst the Trustees, at present, is not rather smaller than would seem desirable in the case of such an institution?—I think that if the constitution of the British Museum were to be considered afresh, undoubtedly a reduction in the number of the Trustees might well be made. Practically that is provided for by the appointment of a Standing Committee, 15, I think, in number, in whose hands the whole executive control is.

13,544. The appointments are made by the three Principal Trustees, who are, I believe, the Archbishop of Canterbury, the Lord Chancellor, and the Speaker; considering that they all have so many other very important duties to perform, does your Lordship think that that is the best mode in which the appointments could be made?—Practically I take it that those appointments are made upon the recommendation of the permanent officers of the Museum; undoubtedly the three eminent persons whom you name cannot be expected to give very much of their time to the matter. On the other hand, they bring to such decisions as they have to make an entire impartiality and superiority to all small personal influences.

13,545. As regards the subordinate appointments, I presume that the Trustees are very much guided by the heads of departments, but the choice of the heads of departments rests also with them, does it not?—I presume it does.

13,546. You are probably aware that in consequence of the expense of printing, and especially of illustration, scientific societies are often unable to publish with all the detail and all the illustration which they could wish, some of the investigations and observations which are brought before them, and which, if they had more ample funds, they would be glad to print in their Transactions; do you think that there would be any objection to the principle of a grant in aid, say of one quarter or one half of the expense of publication incurred by scientific societies?—I think that if any grants in aid are to be made to scientific societies in addition to the sums which some of them now receive, it would probably better be made in a general way, not specially limiting it to assistance in publishing, but as a contribution to their general purposes.

13,547. The Geographical Society is, I think, the only scientific society in England which has any direct pecuniary aid from the Government, and then it is considered that the map room of the Geographical Society being open to the public is an equivalent for the 500*l.* a year which the Government pay to the Geographical Society?—The Geographical Society, as I understand, consider it as an equivalent transaction, as a bargain and not as a favour; but I am under the impression, I may be mistaken, that various other societies receive lodgings rent-free, allowed them by the State, which, of course, is pecuniary assistance in another form.

13,548. If the assistance given to the societies with regard to their publications were limited to a certain proportion, would there not be a guarantee that the societies would not print any papers that were not in their opinion worthy of publication, because, of course, the expense would, to a considerable extent, fall upon themselves, and, therefore, it would be, in a certain sense, a self-regulating system?—I think that the scientific societies would think twice before they accepted a grant of that kind, because wherever assistance is given there is a right of interference. I do not know whether they would desire to be placed under any direction, or to receive any instructions or hints which would be equivalent to orders as to what they should publish, and what they should not.

13,549. Do you not think it would be possible to

The Earl of Derby, F.R.S.

13 Nov. 1872.

leave the discretion to them, considering that so large a proportion of the expense would fall upon them, and that it would clearly not be their interest to publish any matter which in their opinion was not worthy of publication?—I can only repeat that if they are to receive any additional assistance from the State, I think it would be better to give it not with a special reference to their publications, but in aid of their general funds.

13,550. (*Chairman.*) Have any other points suggested themselves to you in looking over these papers upon which you would like to give us your opinion? —I am not aware that there are, unless I may add one observation to what I have already said upon the question of a scientific council on that large scale which I think has been proposed. I believe that you would have a great deal of heartburning and jealousy on the part of men desiring and failing to get into it; and I think that if you brought together 25, 30, or 40 of the most eminent men in science, it would be found that the practical direction of that body would very likely be in the hands of men who are by no means the highest scientific authorities. The conduct of administrative business and the management of men is an entirely different thing from the conduct of scientific research, and it might very possibly be that those who would take the lead in managing the affairs of such a council would be those whose time and attention were the least devoted to purely scientific work, and who although they might possess a good deal of administrative ability might possibly not by any means stand at the heads of their respective branches of science.

13,551. Some of the witnesses have suggested a much smaller council: for instance, Mr. Farrer, of the Board of Trade, strongly objects to the large council proposed by Colonel Strange, but thinks that a small body of men to whom the Government could have recourse would be of great advantage in conducting the Government business, and I think his proposal is that the Council of the Royal Society should be recognized to a certain degree as the official adviser of the Government; do you think that as much objection applies to that plan as to the larger council that has been proposed by others?—I do not think you can possibly refer scientific matters generally, matters concerning all branches of science, to a more competent body of men than the Council of the Royal Society constituted as it generally is. My objection to giving to that body an officially recognized position as the permanent advisers of the State is this, that you thereby take it out of the power of the Government to say who their advisers are to be, because the members of council are appointed by a process with which the Government has nothing to do.

Adjourned to Tuesday next at ¼ past 11 o'clock.

No. 6, Old Palace Yard, Westminster, Tuesday, 26th November 1872.

PRESENT :

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JOHN LUBBOCK, BART., M.P., F.R.S.	THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.	GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.	

HENRY JOHN STEPHEN SMITH, ESQ., M.A., LL.D., F.R.S.

The Marquess of Salisbury, F.R.S.

26 Nov. 1872.

THE MOST HON. ROBERT ARTHUR TALBOT GASCOIGNE-CECIL, MARQUESS OF SALISBURY, F.R.S., examined.

13,552. (*Chairman.*) The points on which the Commission are anxious to obtain your Lordship's opinion have reference chiefly to certain suggestions which have been made by some of the witnesses who have been examined before us, and whose evidence, I believe, you have seen?—Yes, I have seen the evidence to which your Grace alludes.

13,553. Is it your opinion that the cause of science is hindered by the want of a sufficient career for scientific men?—I believe that that is the case, and I am induced to think so, by noticing how very much more rapid the progress of research is where there is a commercial value attached to the results of it, than in other cases. The peculiar stimulus which has been given to electrical research, in the particular direction of those parts of it which concern the telegraph, is a very good instance in point, and the extent to which researches into organic chemistry have almost clustered themselves round the production of coal tar colours is another instance in point. And therefore it is difficult to avoid the conclusion that research is really hindered by the necessity under which those who are most competent to conduct it feel themselves, of providing for their own support by means of the talent and the knowledge which they possess.

13,554. A large proportion of the men who are inclined to the pursuit of science have also to work hard, have they not, for their livelihood?—That is the case; and I am afraid it is unfortunately also true that those who have not got to work hard in early life for their livelihood, are very apt not to acquire sufficiently severe habits of industry to be able to pursue any kind of research at all.

13,555. Do you hold that the State may legitimately interfere in giving aid to the advancement of science?—I certainly do. It is a very orthodox doctrine to hold, and one which could be supported if necessary by quotations out of Adam Smith, the essence of the doctrine being, that the State is perfectly justified in stimulating that kind of industry which will not find its reward from the preference of individuals, but which is useful to the community at large.

13,556. The State has already, to a considerable extent, recognized, has it not, that duty; and there are a considerable number of scientific institutions supported more or less by the State?—No doubt the State, in the money that it gives, and has given in past times, to the best Universities, has recognized that duty.

13,557. There are the Observatory at Greenwich, the British Museum, and Kew Gardens; you would consider those as instances in which the State aids the promotion of science?—They would be all instances in point; and I do not apprehend that as to the abstract doctrine itself there has ever been any serious contest; it is more the disinclination, natural and right on the part of the State, to spending more money than it can help.

13,558. Amongst the witnesses who have been examined, many of them have been of opinion that further aid is urgently required; would that coincide with your view?—That appeared to me to be the result of their evidence, which I have read, and as far as I may have been able to gather the opinion in other quarters, I think it points in the same direction.

13,559. You would not be disposed to differ from the view which they have expressed?—By no means. I think that it is one of the most pressing wants of our educational system.

The Marquess of Salisbury, F.R.S.

26 Nov. 1872.

13,560. Have you any advice which you could give the Commission as to the best mode in which this end may be attained?—I should recommend that it should be given directly, and with as little concealment by ostensible duties of another kind as possible. I observe that many witnesses, and some of great distinction, have proposed to find the requisite support for scientific men engaged in research, by giving them an ostensible government office of some kind; as, for instance, the institution of a council of science, which should advise some minister or ministers as to the duties that they would have to perform. I cannot concur in that recommendation, because I have never seen anything to lead me to believe that such a council of science would have anything to do, and if any money is to be given, as I think it ought to be given, for the purpose of furnishing a career to men who are really engaged in research which is not pecuniarily profitable, I think that it would be far better given directly and openly, than given under the form of an office which would practically be a sinecure.

13,561. I am not quite sure whether those who recommend the establishment of such a council do so with a view to find a career for scientific persons. Their chief object is, rather, to enable the Government to get good advice on scientific questions?—My experience is very small, but so far as it goes, I should say that the Government would always get better opinions, on any scientific point that arises, by applying to the most distinguished scientific man in that particular branch at the time, than it would by having a set of permanent officers to give advice on such subjects. I think that the analogy of the law is one of the strongest that can be applied. There is no subject on which the opinion of an expert is so thoroughly necessary as on questions of law; but it has never been suggested to appoint a Council of Law to advise the Government departments on questions of law which may arise in the administration of their duties.

13,562. Many of the witnesses appear to consider that the present mode of obtaining advice in the way which you suggest, and which is one which would naturally occur to any one, leads to great uncertainty, and does not, in practice, provide the Government with the best advice, nor such good advice, as they think they could obtain by a council of science; could you give us the benefit of your opinion upon that point?—I do not know whether by uncertainty your Grace means that the scientific men whom the Government may consult may differ in their opinions from other scientific men to whom application might be made.

13,563. I do not think it is so much uncertainty in that point of view, as that questions very similar to each other meet with a different reception,—that sometimes the proposals that are made to the Government are favourably, sometimes unfavourably received; the advice which they obtain upon these questions leads to different results?—But it could hardly be contemplated that any such council could give a stability to the policy of the Government in matters connected with science, because, of course, the stability of the policy of the Government depends upon the stability of our whole political arrangements.

13,564. I think it has been rather pressed upon us, that the establishment of a council of science would lead to scientific questions generally being treated in a more systematic manner than they are at present?—I am afraid that those who give that advice are not practically acquainted with the working of the House of Commons. My impression is, that the House of Commons would never feel itself prevented from reversing the decision of a council of science of that kind.

13,565. In your opinion, is the Council of India a case in point?—I should say certainly not. The Council of India was appointed to meet a very peculiar political crisis, and has very peculiar political duties assigned to it. Owing to the indisposition of Parliament to concern itself closely with questions of Indian finance, there is practically no check upon the Secretary of State from the House of Commons in reference to the financial measures that he might adopt; and a fear was naturally entertained that the Secretary of State, if left to his own absolute discretion, might not be as careful in the administration of the finances of India as might be desired; and, therefore, a veto has been lodged with this council, enabling them to prevent any expenditure of which they disapprove. But no similar difficulty arises in questions of science. There are no large sums of money arising from the taxes of a distant people that have to be expended, and, therefore, no special check is required upon ministers with regard to that matter. The object, therefore, of the Indian Council is one that never could be fulfilled by, or entrusted to, any council of scientific men. Besides that, the Indian Council, beyond its checking power, is really simply a bureau of administrators. The councillors act as under-secretaries; they partition out the enormous business of the India Office amongst them, and they are the working hands of the Secretary of State. They have almost all of them spent the greater part of their lives in performing those very duties which, in later life, they are called upon to supervise; and really they are the parts of a great administrative machine, and, therefore, they bear no analogy whatever to a proposed council of scientific advice.

13,566. Has any parallel occurred to you, which would be more appropriate?—I should rather look for a parallel in idea to the mode in which learning, in another branch of unremunerative study, has been encouraged. There are certain offices in the Church, the existence of which has been, I think, very plausibly defended on the ground that they give opportunities to men to pursue branches of learning for which they could get no reward from the demand of the public, but which it is very desirable, for the Church and for the State, should be pursued. Holding the analogy to that extent, and no further, it appears to me that the same idea might be applied to researches in science. There is the same characteristic common to both, that the research is unremunerative, that it is highly desirable for the community that it should be pursued, and that, therefore, the community must be content that funds should be set aside to be given, without any immediate and calculable return in work, to those by whom the research is to be pursued.

13,567. Would you attach any duties to such positions as you contemplate?—If I could follow out entirely my own idea, probably I should not; but it is necessary to take into consideration the conditions of public opinion among us. If you appointed scientific men to pursue branches of research, imposing upon them no duty whatever to show that they were really doing something, there would infallibly arise suggestions that they were spending their time in idleness, and not working for the money that they received. It would, therefore, for their own interest, and to save them from such invidious comments, be desirable to impose upon them the necessity of publishing, either in the form of books or in the form of lectures (but not sufficient in number really to impede their work), an account of the result of their labours during each successive year. Perhaps one or two stated lectures in the course of a year, to be delivered to University students, would be the best means of imposing upon them that test of industry.

13,568. Would your notion be that such positions, when once obtained, should be held for life?—With provisions for retirement, I think that that would be almost necessary.

13,569. Have you formed any idea as to what sort of income you would attach to such offices?—I should say, taking the parallel to which I have already alluded, that an income of about 1,000*l* or 1,500*l*. a year would be the kind of income which would suffice for the purpose that I have in view.

13,570. I presume that you would not be of opinion that any large number of such incomes should be granted?—Probably not; probably it would be judicious to divide the objects of scientific research into certain classes, and to have one or two men attached

The Marquess of Salisbury, F.R.S.

26 Nov. 1872.

to each of such classes of research; but the number must depend very much upon the funds which you have at your disposal.

13,571. Have you turned your attention to the question of funds?—I consider that the matter is of so great importance to the State that I do not think the slightest hesitation should be shown, if it were necessary, in seeking for the requisite support from the House of Commons; but undoubtedly there would be always the temptation, especially in times of financial pressure, to diminish and pare down any such payments, and if it were possible to provide them from a source less liable to change, it would be very desirable. I see that this suggestion has received a very authoritative assent from a body of academical gentlemen who have assembled to consider what ought to be done with the surplus revenues which are supposed to exist in the two Universities. It is perhaps rather premature to dispose of them until we know what they are; but it is generally believed that after all the fair necessities of the Universities are fully provided for, there will still be a considerable surplus which can be disposed of for the use of direct objects of education.

13,572. The Commission have had a great deal of evidence (which probably you may have come across) from University men, very much to the same effect as those proposals to which you have now been alluding?—I am aware of that.

13,573. I may say that the great preponderance of opinion amongst the witnesses from the Universities who have been examined is, that a larger amount goes in mere rewards than is at all called for, or is desirable—would you be so good as to give us your view upon that point?—Considering the amount of controversy that prevails on University questions, it is astonishing how great an agreement there is upon that point. I have heard from all schools, theological and political, in the Universities, a coincidence of opinion that the present application of the revenues of fellowships is exceedingly unsatisfactory.

13,574. There are one or two other matters to which I do not see any reference in your notes, but upon which the Commission would be glad of your opinion, although the answers which you have already given have shown pretty clearly what your views would be upon them. We have been told that the Government requires a good deal of scientific advice in carrying on the duties assigned to it by Parliament; for instance, Mr. Farrer, who is probably known to you as the permanent Secretary of the Board of Trade, tells us that although in most cases they are able to deal tolerably satisfactorily with the work which is thrown upon them, yet cases of considerable difficulty do arise in which they are very much perplexed; and although, on the whole, he is not favourable to the elaborate machinery of a scientific council, such as has been suggested by other witnesses, yet he does think that something or other is required to enable the Government to deal satisfactorily with such questions?—I cannot help feeling that the difficulty is really, if you pursue it, one rather of money. Government departments have got an idea into their heads, I do not know why, that scientific opinions differ in this from medical and legal opinions, that they have a right to have them gratuitously. I have never been able to understand on what grounds that theory rests; and my belief is that if you would assimilate scientific knowledge to medical or legal knowledge in that respect, you could always get, for a proper remuneration, the very best scientific opinion that the country is able to furnish. You cannot expect that you should be able to make upon a man, every moment of whose time is occupied, a demand involving his time for hours or days of research, if you are not prepared to behave to him as you would to a lawyer in a similar case.

13,575. You have probably observed also, that some of the witnesses think that several other Government establishments for the advancement of science are needed, further observatories, further laboratories, and other institutions. If any strong case were made out, do you see any objection in principle to the establishment of new institutions of that kind?—Far from it; always reserving the rule that where there is the least likelihood of such institutions being set up in answer to private or commercial needs, the Government should have nothing to do with them; but some of these institutions which have been alluded to in your Grace's question, especially observatories, clearly fall within the duties of the Government; and certainly, from all that one hears, it is probable that their duty in that respect is inadequately performed, and that observatories for a much larger range of observations might with great advantage be multiplied. With regard to laboratories I speak with very little knowledge, but I should have thought that, excepting in connexion with places of education, they were not required, because the demands of commerce upon chemistry are so large at present, that first-rate laboratories receive constant and full employment; but of course that consideration does not hinder their being supplied at places where education is carried on. There is another point in which I think that the Government might give an advantage of an educational kind to scientific research. It would be desirable, if it were possible, to provide the means of giving scientific instruction to instrument makers. My impression is that their importance to the conduct of scientific research is scarcely sufficiently recognized by the public, and that it is, I will not say quite, but almost of equal importance, to have highly educated and cultivated scientific instrument makers, as to have highly educated scientific thinkers.

13,576. Some of the witnesses have attached a considerable degree of importance to placing all institutions of a scientific character, aided by the State, under one minister. At present they are distributed amongst different departments, and some are under no department at all; as, for instance, the British Museum, which is managed by a body of Trustees, although aided largely by Government money. Kew Gardens are under the Board of Works; Greenwich is under the Admiralty, and the Meteorological Department is under the Board of Trade?—The question is, of course, whether Government by trustees, or Government by a department of the State, reaches its object with the least friction. I should have said that Kew Gardens were on the whole managed with more friction than the British Museum.

13,577. Some witnesses who have given us their opinion upon the point, would like them all placed under the charge of the Minister of Education, or under a new Minister of Science, as some suggest; but, at all events, under a minister whose business should bring him directly into contact with science, whereas the Board of Works has no direct connection with science?—I do not see practically, from my knowledge of the working of the House of Commons, what advantage would be gained by it. Of course it is very desirable that the business of the Government should be properly classified, and it might be, therefore, desirable that, as much as possible, all these institutions should be brought under the administration of one department; but the setting up of a special minister is a very favourite recommendation in behalf of any interest which does not think that sufficient attention is paid to its demands. But I do not see the practical advantage of it. The minister would sit in the House of Commons, and he would answer questions, but I do not know why he would do the work any better than it would be done by the present Council of Education.

13,578. Many witnesses are of opinion that all those Government institutions of a scientific character should be placed under the Council of Education and removed from such a department as the Board of Trade, for instance, or the Board of Works; do you concur in that view?—The Council of Education has this one peculiar qualification for managing well scientific affairs, that, undoubtedly, in dealing with men of very high eminence and culture, very great deference and courtesy are necessary on the part of the minister, and the Council of Education have now for 30 years

The Marquess of Salisbury, F.R.S.

26 Nov. 1872.

past dealt with the clergy in all parts of the country, and that duty, I think, has made them particularly careful of giving offence, and particularly capable of avoiding anything that could offend legitimate susceptibilities.

13,579. (*Sir J. P. Kay-Shuttleworth.*) With reference to his Grace's last question, some of the witnesses have suggested, with respect to the British Museum, that some functions are not now discharged by the British Museum which might be discharged by it, as, for example, the formation of local museums by the distribution of duplicate specimens, the development of the educational power of the museum by the establishment of lectureships within it for popular instruction, and other similar means of rendering the British Museum more an instrument of public instruction; and, perhaps, their desire to give the Committee of Council on Education some power over the British Museum has arisen from their wish that the British Museum itself might thus become an instrument for diffusing information amongst the public. Has your Lordship formed any opinion upon that subject?—With respect to specimens, I apprehend that the British Museum generally buys its specimens, and if it has duplicates it would probably be willing to sell them to any local body that would be willing to buy them; but it would hardly be fair that the central body should buy, and that the local body should receive gratuitously.

13,580. Some of the witnesses have suggested that if the British Museum were to invite more generally the contribution of specimens, as, for example, the Museum at Kew does, there would be a very large number of duplicates in many departments, but that the Museum has rather had a tendency to go into the market without employing all the agencies that were open to it to secure specimens?—I have heard of a case in which the British Museum went into the market and bid at an auction against the South Kensington Museum. I think it would be very desirable that a central management should interfere to prevent transactions of that kind, but otherwise I cannot think that there would be any wisdom in withdrawing the British Museum from the government of a body like the Trustees, who have, on the whole, done very good work, and with an amount of stability that you would look for in vain in an officer of the Government.

13,581. Nor would you recommend any combination of functions, there being at present no connexion either direct or indirect with the Education Department?—It might be very easy to make a very practical connexion by enacting that the President and Vice-President of the Committee of Council should always be Trustees of the Museum, and they would then have direct formal access to the body of Trustees.

13,582. (*Professor Stokes.*) With reference to the procuring of advice in scientific matters by persons connected with the Government, your Lordship drew a parallel between that advice and the advice which is required on legal matters: is there not this difference, that in the case of a legal difficulty the Minister, or whoever he may be who is connected with the Government, knows precisely what the difficulty is, whereas in a scientific matter he might, possibly, from the nature of his early education, be very much at sea, and not know to whom to apply; and, then, if he does apply, no one man of science is omniscient even in his own department, and it might be that the person to whom he applied, although very eminent, might happen to be unacquainted with some particular point, which might be mentioned if a body of three or four persons connected with the same science were to meet together; might there not, on this account, be some advantage in having a board, or an assemblage of persons not very formally constituted, whom the Minister might consult when the occasion arose, without any view whatsoever of seeking in the appointment of such a board merely a means of support for scientific men, but, in point of fact, making the remuneration, we will say, dependent upon attendance, and merely a sort of consideration for the time spent?—I do not think that there is any difference in that respect between law and science. It is equally true that no lawyer is omniscient, and he certainly does not know the law beyond his own special department, but the difficulty is met where a case belongs to several departments by then seeking the advice of several lawyers. It is a matter of constant experience that an opinion is signed by three different lawyers in three different departments of the law. In like manner, if a matter touched upon electricity and meteorology and chemistry, you would get the opinion of a chemist, a meteorologist, and an electrician. With reference to the possibility that the members of the council might correct the opinions of each other, undoubtedly that, to some extent, is true, but I doubt whether the advantage would not be outweighed by the danger of having, on many points on which a minister might refer, a series of minority reports. Supposing a council of 12 or 16 scientific men: although undoubtedly upon a great number of matters they would be unanimous in opinion when they were dealing with that which is known and accepted as scientific fact, yet on all the border points between knowledge and speculation their opinions would most probably differ, and the position of a minister who had before him two or three sets of opinions, in entirely opposite directions, would not be much more hopeful than that of a minister at present who has no opinions at all.

13,583. Even in that case would it not show that the point was really one of very great doubt, whereas if he obtained the opinion of one man he would have nothing to guide him but that one opinion, and he might suppose that it was a matter of certainty and proceed upon that supposition, whereas if he saw that it was a matter of very great doubt he would exercise greater caution?—The question is difficult to answer in the abstract, because I do not know in what individual cases the difficulty and need have been found to arise. There is the well-known case of the lighthouses, in which the Board of Trade again and again consulted scientific men. It consulted Professor Faraday in the first instance, and afterwards Professor Tyndall, and I never heard any reason to believe that it had grounds to be dissatisfied with the opinions which it obtained. Nor is it easy to suppose that the opinions would have been more valuable if they had been discussed among a large body of scientific men. Whatever errors there may be in the opinions of one individual, at least they have an unity and a courage which is very often wanting to the compound opinion of a dozen men.

13,584. In the case of the lighthouses, was there not a commission appointed?—There was a commission which took advice, and the advice taken was that of Professor Faraday in the first instance, and I think of Professor Tyndall in the next, but I speak from general recollection. I may be wrong. I merely remember reading their opinions amongst the parliamentary papers that were circulated.

13,585. (*Professor Smith.*) Your Lordship has already expressed your concurrence in the opinion that in certain directions there is probably a very considerable waste of academical funds, and that a certain proportion of that which is now probably wasted might be rendered more directly useful for educational purposes in the first instance?—My knowledge on that matter is of course only the knowledge that a man can derive from cases within his own observation, but from all that I have heard I believe it thoroughly to be the case.

13,586. Has your Lordship's attention been directed to the fact that in the University the amount of scientific teaching which is provided is very small, viewed as a matter of quantity, as compared with the amount of teaching that is provided in other subjects?—It is, I should say, a matter of notoriety, that the teaching provided at Oxford in scientific matters is most of it of very modern institution, and, as yet, bears a very small proportion compared to the teaching provided for the more ancient subjects of study.

13,587. Then you would not be indisposed to think

The Marquess of Salisbury, F.R.S.

26 Nov. 1872.

that it would be right, if there should be found to be surplus funds available, that a very considerable proportion of those funds should be diverted in the direction of these newer branches of knowledge?—Clearly my view is that whatever surplus funds may be found to exist, the first claim upon them is for the teaching power of the University in all the subjects in which the University ought to teach, and when that has been fully satisfied it is very likely that there would still be a surplus, which might be applied in the manner which I have suggested.

13,588. It is of course very necessary to teach students the methods of research, after they have received such a training as qualifies them for a degree or for a high honour, but they still have to be taught, so far as it can be taught, how to become original workers; and it has been suggested to the Commission that the only way in which that can be done is by placing such young men under the care of a Professor who is himself actually engaged in original research, and whose principal duty original research may be, but who, nevertheless, should have as a part of his duty the training of young men in those methods. Have you ever considered that to which our attention has been directed by some of the witnesses, namely, whether the functions of research might not be very advantageously combined with a certain class of educational functions?—There is no doubt that the duty of education and the duty of research can be profitably combined. The great danger is that the education will be made to occupy so large a part of the man's time that his leisure for research shall be insufficient. Everybody conducting any kind of research will require the assistance of apprentices, and up to a certain point they will not only not hinder but they will be useful; but it is very conceivable that a man might be required to receive and educate so many young men in the character of assistants, that practically his own time and thought would be entirely engrossed; but, subject to a precaution against any such danger, I quite concur that the combination referred to would be a very profitable arrangement.

13,589. Another difficulty has been stated, as to which I should be glad to hear your Lordship's opinion, with regard to establishing places at which the exclusive duty should be original research, and the difficulty is this, that there are very few men, if I may so say, who have originality enough to occupy their whole time, or who can profitably devote the whole of their time to original research, and it is said, although I do not know with what truth, that many men who have a great deal of scientific originality, are, nevertheless, the better for not having their whole time absorbed by original work, and that they require a change of work of some other kind; that has been given as a reason why an effort should be made to combine the functions of original research with some light duties of a professional or educational kind in order to obviate that supposed danger?—That is a subject on which no one could really give evidence who was not an original seeker himself; but, so far as I have observed, persons engaged in original research are apt instinctively to seclude themselves, and keep themselves away from all other objects of attention which might dissipate their thoughts. But, in any case, it would be wise not to appoint persons to those posts of research until they had first proved themselves, without such assistance, to be capable of devoting by far the larger part of their strength and attention to that duty.

13,590. In speaking of the establishment of laboratories by the State, your Lordship appeared to me rather to refer to chemical laboratories; but it has not escaped your attention, I am sure, that the cost of physical apparatus is so very great as to put physical inquiries really out of the reach of a very large number of persons who probably might be capable of conducting such researches; and in consequence of there being no such assistance assigned to such persons as a State laboratory, in which they could obtain the use of apparatus, and of a really fitting building, constructed with sufficient solidity for the purposes of research, a great many persons are prevented from entering upon researches of that kind by the want of means; and it has been contended that by providing laboratories, at the expense of the State, you would be doing no more for such persons than has been done for learned men by providing them with great public libraries, as you would be only providing them with the opportunities of research, which otherwise they could not have?—My fear would be that there would be a difficulty in providing laboratories in sufficient numbers to satisfy all, as you can provide books at the British Museum to satisfy all, and that the result would be that very often those who are least fitted to obtain any useful result would engross the instruments. For the purpose of really first-rate workers, I think that the Government might very advantageously be liberal; but such liberality I think would best take the form of an increased grant to the Royal Society. But I should be doubtful whether it was possible by any moderate expenditure of funds to provide an expensive class of scientific instruments of all kinds for all the persons who might be inclined to use them.

13,591. *(Professor Huxley.)* With respect to the question of what we may call "scientific deaneries," does not this occur to your Lordship as a possible objection: that, even as it is said elsewhere, deaneries are not always occupied by men who have devoted their lives to abstract research, so there would be a danger that, in the scientific world, interest with a Minister, or interest in the House of Commons, might lead to the appointment of a man who was below the mark of those scientific persons to whom the Minister would properly give such an appointment?—There would undoubtedly be that danger attaching not only to ministerial appointments, but to every other kind of appointment that it is possible to make. The only answer that I can give is, that it seems happily to be the case that jobbery has constantly diminished in the bestowal of the higher appointments in this country for many years past, and one hopes that that salutary process will continue.

13,592. On the other hand, when there is connected with a scientific post the duty of teaching, or of making some kind of appearance in public, by which public opinion is brought to bear upon its holder, there is surely more check upon jobbery than there is in cases where a man is allowed to receive an income and to do pretty much what he likes with it?—No doubt, and one might give as an instance in support of that view the case of the judges, whose appointments I suppose are less jobbed than any other appointments in the world; but in the view that I suggested I said that it might be, for the satisfaction of the public, desirable that a certain amount of public appearance should be exacted from the persons who were appointed.

13,593. Your Lordship suggested that they should be required to give not more than one or two lectures a year, but I presume that you would have no objection to extend that obligation so as to make it a real and clear responsibility to the public?—That would be a matter for careful consideration. The object would be to combine the utmost amount of responsibility with the smallest claim upon the person's time.

13,594. I think one argument which has been most frequently brought forward by the witnesses in favour of a scientific council for advising the minister, in preference to the present method, is the fact that if you had a scientific council whose proceedings were more or less public, they would be under the check of public opinion, whereas at present the scientific adviser to whom the minister goes is under no check whatever; does that consideration strike your Lordship as one of some importance?—I do not think that among the many merits of the Indian Council their being under the check of public opinion is considered to be one of the highest importance.

13,595. I myself have nothing to say about the

The Marquess of Salisbury, F.R.S.

26 Nov. 1872.

analogy of the Indian Council with the proposed Scientific Council; but supposing a scientific council to exist, whether it be analogous to the Indian Council or not, would there not, in the fact of the publicity of the proceedings of this scientific council, be an amount of check upon its proceedings which I apprehend does not exist in the case of the Indian Council?—I am afraid that you would have to admit reporters, and if you did that the duties of the council might not be conducted with that rapidity which would be necessary for efficiency.

13,596. But without admitting reporters, would not the published report of the proceedings of the council be a sufficient check—for example, you are aware of the manner in which the business of the Government Grant Committee is transacted, and that, although no reporters are admitted, their proceedings are virtually public, that is to say, the results are all published?—I do not think that there is any public check upon the Government Grant Committee. There may be a governmental check, but the public at large know very little of its proceedings.

13,597. But the Fellows of the Royal Society who are interested in it know all about it?—Yes, no doubt.

13,598. So that if the Government Grant Committee made recommendations which could not be justified the fact would become public?—But the most efficient kind of committee is one with a very efficient chairman, the rest doing nothing at all. A committee of that kind would make a very good show indeed in public, but there would be no check whatever on the efficiency in scientific worth of the silent members of the committee. The published reports of the committee test the doings of the committee as a whole, but they would have nothing or very little to do with testing the doings of individual members.

13,599. Still that is an ideal committee, and one which very rarely exists in practice; it generally happens that a member of a committee has something to say as to the decision of the chairman?—Yes; but I think it generally happens that the strong members of the committee do all the work which the weak men shuffle out of very much. A committee which shows very good results in public may be very largely composed of inefficient men.

13,600. (*Chairman.*) I think that what has been proposed by the witnesses who recommend a council is, that in every case in which an opinion is asked they should furnish a report of the reasons for the advice which they give?—I am afraid that if the council were constructed on that principle, the ministers, who usually have their time very fully occupied, and are desirous to avoid work as much as possible, would consult the council as little as possible.

13,601. (*Professor Huxley.*) Is your Lordship acquainted with the machinery of the Government Grant Committee?—Not very closely, only generally.

13,602. Do you consider that that is a good mode of administering funds which are granted by the State for scientific purposes?—As far as I know, exceedingly good.

13,603. Supposing that any larger funds than the present very small sum were granted annually by Parliament for the advancement of research, do you think that the Government Grant Committee would be the best channel through which these funds should be administered?—I think that no better could be found. There is no body which is so thoroughly well constituted for the purpose of representing the scientific world as the Committee of the Royal Society.

13,604. You prefer that to any new fangled scientific council?—Yes, certainly. We know how it works, and it would be pretty sure to go on working as well as it does now.

13,605. At present I am given to understand that all the appointments at the British Museum are made by the three principal Trustees, who are the Archbishop of Canterbury, the Lord Chancellor, and the Speaker of the House of Commons; and, the body of Trustees not being represented in Parliament by any responsible officer, there is of course no direct check upon the proceedings of those who make the ultimate appointments. I have nothing to say as to the excellence, or otherwise, of the appointments thus made, but do you think that this is a good way of administering the affairs of a large department such as the British Museum?—Theoretically it is almost grotesque, but in practice I have always heard that the appointments are singularly well made.

13,606. Your own opinion, therefore, would not lead you to suggest any alteration in the mode of administering the affairs of the museum?—I am disinclined to make an alteration, except where there is a grievance shown. If the affairs of the museum are not well administered, by all means alter its government, but when a thing has fitted itself by a process of mutual compromise and arrangement to the demands that are made upon it, I think it is very undesirable to interfere theoretically.

13,607. Do you think it desirable that the British Museum should go on as at present without anybody exactly responsible for it in Parliament?—The real meaning of the word "responsible" is "liable to answer questions," and I do not think that the duty of answering questions has really exercised much check upon the public departments which are submitted to it.

13,608. (*Sir John Lubbock.*) I rather gather from what your Lordship has said, that if the Council of the Royal Society thought that a rather larger amount might well be allotted, say 5,000*l.* or 10,000*l.*, instead of the 1,000*l.* which is now granted for scientific research, you would be disposed to recommend an increase of the grant?—Yes, certainly. I think that it ought to be largely increased.

13,609. With reference to the scientific appointments which you have described in the earlier part of your evidence, if funds were set aside to provide an income for a certain number of scientific investigators, would you make it incumbent upon the holders of such posts to give the Government the benefit of their advice and assistance upon any points which fell within the scope of their special subject; or would you prefer that they should not have any such duties thrown upon them?—It had never occurred to me, but I think it would be a very fair and salutary provision that they should do so.

13,610. If the funds were obtained for those appointments by some re-arrangement of the University endowments, as has been suggested, would you still leave the nomination in the hands of the Prime Minister?—On the whole, I think my experience is that those nominations which are made in full view of the public are better made than any other nominations, and if there is no practically ascertained ground of complaint, I should recommend that they should be in his hands.

13,611. If those appointments were left in the hands of the Universities, there would be a natural tendency, would there not, to appoint those connected with the particular University?—Yes; that is to say, the pressure upon the University authorities to do so would be very great.

13,612. You have indicated the opinion, I think, that the two older Universities would do well to give more weight to scientific subjects in the management of the University studies and rewards than has been until lately the case?—Yes, but I think that that necessity is more and more felt, and is obtaining increasing recognition every day.

13,613. That, of course, is quite independent of any question as to whether there are any surplus funds, or not?—I could not recommend anything so revolutionary as turning the Professor of Greek into a Professor of Physical Science; but if there are fresh funds, I think that physical science clearly has the first claim.

13,614. No one, of course, would contemplate any interference with the existing holders of University chairs, or with individuals; but in considering the system, it would be independent of individual considerations of that character?—I should certainly be

The Marquess of Salisbury, F.R.S.

26 Nov. 1872.

loth to interfere even with an existing chair, unless it were shown that the chair was not administered at all. The great thing which I think it most desirable to avoid is the raising up of parties in favour of this class of teaching, or that class of teaching, within the bosom of the University, and any such measure as that would be exasperating, and would infallibly have such an effect.

13,615. Do you not think that the system of studies at the University should be based upon general considerations, rather than upon the accident of particular endowments?—If I were forming an University in the first instance, undoubtedly so; but I should be very apprehensive of disturbing existing arrangements, on account of the bitter feeling which it would be apt to excite.

13,616. But if it is a question of reform?—If I were reforming it in the etymological sense of the word, undoubtedly I would give more prominence to physical science than at present exists.

13,617. (*Dr. Sharpey.*) With reference to those scientific appointments which you have suggested in the early part of your evidence, would you consider it advisable that there should be any definite number of them, so that when one of them became vacant it would be required to be filled up by a fresh appointment, or that the appointment should simply be made when cause arose, when the individual claims were of such a nature that the minister was justified in making the appointment?—I think that the latter course is too invidious for our political machinery. It would be absolutely necessary to shield the minister from the charge of making a place for the sake of gratifying his own inclinations by appointing an individual to it. The vacant place should always be filled up.

13,618. Does your Lordship think that there would be no risk in the case of a vacancy occurring that it might be inadequately filled up?—I would never say that of any human appointment, but I think that on the whole the appointments by the Ministry of the day have been quite as well made as by any other appointing authority.

13,619. I am not at all presuming that the patronage could be better placed than with the responsible Government of the day. I mean that in case of a vacancy occurring, which must be filled up, there might not be an individual ready and suitable to be put into that position?—That is a difficulty which undoubtedly occurs, but it occurs in all other departments of learning, and I do not think that you could avoid it in this.

13,620. (*Chairman.*) You are probably aware that some years ago the Government gave 120,000*l.* to Glasgow University, to provide it with new buildings, and it was given on condition that an equal amount was raised from private sources, and we have had evidence before us from many of the Scottish Universities that, as a rule, they consider themselves very poor and very insufficiently supplied with buildings. Do you think that assistance in some shape, either to the Scottish Universities, or to other institutions of the same kind, is objectionable?—The objection would arise simply on the financial ground that it would be very difficult to mark out a line for separating these particular cases off from all others, and that you might find yourself launched upon a scheme of expenditure which might seriously hamper the Chancellor of the Exchequer.

13,621. Do you see your way to laying down any principle or rule which might guide the Government in such cases?—I think that you can lay down a principle with respect to the Scotch Universities; for instance, it has so happened that in ancient times whatever endowments were possessed by learned bodies were not preserved as the endowments in the southern part of the island have been, and that that country having been less rich, there were much fewer endowments of any kind. It might thus be possible to make out a special case for Scotland, although it would meet with considerable jealousy; but I think that to lay down the principle that you will subsidize any educational institutions which you could not bring into such special case, would expose you to a very large expenditure, much greater than Parliament would ultimately consent to endure.

13,622. Is there any other point which occurs to you on which you would be willing to give the Commission the benefit of your views?—No; I do not think that there is anything more that I could say that would be of use to the Commission.

Adjourned to to-morrow at two o'clock.

No. 6, Old Palace Yard, Westminster, Wednesday, 27th November 1872.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., SEC. R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., F.R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., LL.D., F.R.S.

The Right Hon. SIR STAFFORD H. NORTHCOTE, BART., C.B., M.P., examined.

Sir S. H. Northcote, Bart., C.B., M.P.

27 Nov. 1872.

13,622*a*. (*Chairman.*) I believe you have had the goodness to give your consideration to the proposals which have been submitted to the Commission by some of the scientific men who have given evidence before us?—Yes; I have seen some of those proposals.

13,623. The proposals generally are based upon the assumption that the State has duties to perform in relation to science; are you prepared to agree in that assumption?—I am rather chary of the use of the word "duty;" my impression would be that it is desirable that the State should do what it can, both to promote scientific education and also to assist in the prosecution of scientific experiments and inquiries, when they can be best prosecuted by the aid of the State; and I also think that it would be important that the State should have the means of obtaining scientific assistance for the discharge of such of its own proper functions as involve the necessity of scientific assistance.

13,624. Without insisting on the word "duty," how far should you be disposed to admit that it is reasonable that the State should promote science, or what do you think would be the best way in which the State could do so?—I think that if the State charges itself with the promotion of education generally in the country, it would be quite fair and reasonable that it should promote education in science along with education in art or education in other matters; and that whatever the State can do either through its educational department or by encouraging scientific education at the Universities, or in public schools, or elsewhere, it should do.

13,625. Can you point out in more detail in what manner you think that the State could best encourage scientific education?—I am not sure that I could say much as to direct scientific education by the State, except through the sort of machinery which is now employed at South Kensington, and which is very successful as far as the teaching of art goes in the country, *Sir S.H. Northcote, Bart., C.B., M.P.*

27 Nov. 1872.

and, to a certain extent, in the way of teaching science. Perhaps, more might be done in that way. Indirectly, I think that a good deal might be done by a stimulus being given to scientific teaching in the Universities.

13,626. What should you say to the question of the State giving pecuniary aid to new institutions, such as Owens College, or the College that has been founded at Newcastle, or, indeed, to some of the old institutions, the Scotch Universities, for instance, which, generally speaking, are very poor; do you think that it is a legitimate application of the public money that some of it should be granted to Universities, or colleges of that kind?—I think that it would be a very fair application of the public money.

13,627. You do not see any objection to it in principle?—Not in principle, certainly; but I should prefer to see the present endowments for education rather more utilised for the purpose of scientific education than they are, before any direct votes came from the public money.

13,628. So far as I am aware, the only case in which the public money has been granted for that purpose of late is the case of the University of Glasgow, in which a grant of 120,000*l.* was given by the State for new buildings, on condition that a similar amount was raised in the locality; do you approve of such application of the public money?—I am not particularly well qualified to speak upon these subjects. It is not a matter which has come before me in any way.

13,629. There is a second way, is there not, in which you think that the State might promote science?—Yes, that is with regard to the prosecution of inquiries, in cases where the inquiry can best be prosecuted through the aid of the State, or perhaps can only be prosecuted through the aid of the State. For instance, in such cases as meteorological observations upon a large scale · these, it is obvious, can be prosecuted by the State through the agency of the captains of vessels or officers at the service of the Government, and could not be so well prosecuted, or, perhaps, not prosecuted at all in any other manner. And many other cases might be mentioned in which the machinery which is at the command of the State is the only machinery that could be employed, I suppose, for producing the results which are desired. In those cases I think that it is desirable that the State should place that machinery at the disposal of science, so to speak, for the purpose of prosecuting inquiries and experiments, provided that the State is well assured that those experiments are worth prosecuting, and that the methods in which they are to be prosecuted are the best that are known at the time. For that purpose, I think that the State requires advice and assistance.

13,630. Besides objects which are strictly within the limits of what you have been speaking about, other proposals have been made to us, recommending that the State should establish new institutions of various kinds for the promotion of science, with regard to which there is such extreme improbability that they will be undertaken by any other body, that the witnesses have strongly urged upon us the importance of their being founded by the State. Such, for instance, as additional observatories, having somewhat different objects from existing observatories, and the establishment of laboratories, and other proposals of the same kind, some of which you may have observed; do you see any decided objection to the public money being applied for those purposes?—I cannot say that I see any decided objection to the public money being applied for those purposes, but the leaning in my own mind would be against applying the public money in any case where the work could be done without it.

13,631. I think we have had a great preponderance of opinion that there is a great deal of scientific work that might be done in this country which will not be done in all probability unless the Government lends its assistance in some shape; would you be inclined to agree with that opinion?—I think that is very probable, but I should be indisposed, or I should be slow, to say that the Government should take up work of that kind, unless probably with direct reference to some important national object.

13,632. The old observatories were chiefly for direct astronomical observations, but a new branch of astronomical science, which may be called the physics of astronomy, has lately sprung up, and has made great progress, and we have had a very decided opinion expressed that that branch of science is not likely to be prosecuted to the extent to which it undoubtedly might be, unless observatories for the purpose are established by the State; is that a point upon which you could express any opinion?—I do not think I could, because I have not sufficient acquaintance with the subject to know what the relative importance of such inquiries would be. I would only say, generally, that I think that a considerable call might probably be made upon the State for objects which I think are more important, and I think that if you try to do too much you may fail in getting anything done.

13,633. If the State undertakes any duties of this kind, in your opinion would it be necessary that some provision should be made for its obtaining proper scientific advice?—I think so, certainly; and I think that with regard to the duties which it actually does now undertake such advice is necessary.

13,634. In your experience of official life, have you found any instances in which the present arrangements for obtaining advice for actual administrative purposes are unsatisfactory?—Yes, very much so. It seems to me that a minister who is placed at the head of a department in which any work involving the necessity of scientific knowledge is done, often finds himself in a most disagreeable and helpless position. He comes to the place, having had probably a classical education, and having turned his attention to questions of State policy, and other matters, but probably not knowing his A B C in science, not knowing, possibly, the difference between physics and physic; and then he suddenly finds that in his Department a good many things have to be done which here or there involve the necessity for some scientific knowledge. He finds in his Department, perhaps, some secretary, or chief clerk, or other person, who has had a little acquaintance with what has been done in this way in the Department, who has acquired more or less familiarity with it, and who, being an one-eyed man amongst blind men, is thought a great deal of as a scientific authority. Then comes the question as to what is to be done, and the chief of the office goes to this secretary, who tells him with more or less confidence that such and such things are the right things to be done, and that he is a friend of professor somebody, or professor somebody else, who also agrees with him, and the chief of the Department is placed in very great difficulty, because he is incapable of discerning between the merits of two professors. I know that I myself once or twice came across important questions, involving, in one instance, the question of laying a new telegraph cable. There was a great deal of doubt at the Treasury, when I was Secretary to the Treasury, as to which would be the best course for laying the cable which was then talked of from Falmouth to Gibraltar. For various reasons it was thought best that it should be done by the Government itself rather than through a company, and I found myself plunged in all sorts of questions involving a knowledge of electricity, and the advantage of this or that or the other kind of covering, and so forth. I knew nothing about it at all, but I had the assistance of the advice of one or two men, who, I was told, were good men. Afterwards we were told that we had not consulted the right men, and that if we had consulted somebody else it would have been done quite differently, and that we had made a great many mistakes. I do not know whether we made a great many mistakes or not, but I know that I was quite in the dark as to whether we were really going the right or wrong way to work. I found myself again (this was not so much a question of science, but it is an illustration in a cognate

Sir S. H. Northcote, Bart., C.B., M.P.

27 Nov. 1872.

question), when I was at the Board of Trade, many years ago, in a very peculiar position with regard to teaching in art. The School of Design, at that time, was under the Board of Trade, and a question had arisen upon what principles the teaching of ornament should be conducted. The object with which the school had been established was to improve the ornamentation of our various manufactures, and a school was established with a Council of distinguished gentlemen at the head of it, but there came to be disputes as to whether it was necessary to teach the drawing of the figure as the foundation of the drawing of ornament, and it really ultimately came to this, that I, who knew nothing whatever about art, had to advise the Department which was responsible for spending the money, whether the gentlemen who said that teaching the drawing of the figure was necessary, or the gentlemen who said that it was a waste of the public money, were right. And so I could mention a good many other cases in which such is the case. For instance, with regard to the gas companies,—when I was at the Board of Trade, there was a question of regulating the gas companies, and questions arose as to whether it was possible to provide good gas on certain terms, and so forth. On all those questions, which a responsible minister has to deal with, he had no other adviser than somebody in his Department, and some man with a name in science who was recommended to him from outside. He does not know the difference between one man of science and another, any more than he does the difference between one fixed star and another. He knows that so-and-so is a great man, but whether this is his speciality, or whether he is quite the right man to consult on the point at issue, he is really quite in the dark.

13,635. Are you prepared with any suggestions as to the remedy for this state of things?—I can hardly say that I am. I have seen the suggestion which has been made that the Government should nominate a council of scientific people who should assist them in that way. I have great doubts whether such a council would work well, whether it would be easy to constitute it, or whether, if you did constitute it, it would work satisfactorily. My own leaning would be to throw the responsibility, as now, upon the heads of the different departments, leaving them to get the best scientific assistance they could, but providing for the maintenance of such relations between the Government and some scientific body external to the Government, such as the Royal Society, perhaps, as would enable the Government to take advice from that society as to the best men to consult, and also as to the possibility of the work that was proposed to be undertaken.

13,636. If the duties of the Council of the Royal Society, supposing an arrangement of the kind were made, were to become considerable, might there not be a difficulty in calling upon them to discharge such duties without any payment, and would it not be a matter of considerable difficulty to pay a body constituted as the Council of the Royal Society is?—I am not sufficiently aware of the constitution of the Royal Society to be able to speak to that; but I should have thought that some kind of payment might be made to the society, which the society might expend, and by employing such officers as it thought proper to keep all the correspondence, and to refer it to the proper persons; and then, my idea would be, that supposing at the Board of Trade, for instance, some new question arose upon which scientific information was wanted, the President of the Board of Trade would write to the Council of the Royal Society, and would say, such and such business has to be done, and I want such and such advice. Then the secretary, or whoever it might be, would bring the subject before his council, and would write back, What you propose appears to be feasible; you ought to consult Mr. so-and-so, or professor somebody, and you would then be placed by an independent authority in correct relations with the proper man to deal with the subject. Then it would be a question of remunerating that gentleman by a fee, as you would remunerate a lawyer by a fee, for the service which he was to render.

13,637. You see strong objections to any council nominated by the Government; perhaps you may have observed that the proposals laid before us by the witnesses have taken a good many different forms, some recommending a very extensive organisation, others one of a much more limited extent; but your objections would apply to a council in any shape nominated by the Government?—Yes; I think that it would cause jealousy on the part of the departments; and I think that it would also very likely cause jealousy on the part of other men of science. That is a point upon which I cannot so well speak, but I feel sure that there would be a great deal of jealousy on the part of the departments if any council were appointed to regulate the conscience of the Government in scientific matters, and to say how money ought to be spent, what money ought to be spent, and what ought to be done, and what ought not to be done. With regard to that case of which I was speaking, of the School of Design, I know that there was very great jealousy at that time. The organisation of that council was this:—A certain number of eminent architects, sculptors, and painters, and other persons were put upon it, and they partly fell out among themselves, and then it was necessary for the President of the Board of Trade, who was responsible for the spending of the money, to side with one party or the other, and to decide what was to be done, which he was, of course, not very competent to do. Then came a great deal of external jealousy on the part of the other artists whose views were set aside, and there was, at the same time, a good deal of jealousy on the part of the Board of Trade, it being told that because these artists held this and that, therefore they were to spend the public money in this way or the other way. Similarly, I might mention as an instance in which I saw the germs of jealousy, the Committee of Military Sanitary Organisation, which is referred to, I see, by Captain Galton in his evidence. Whilst I was at the India Office it was perfectly true that a great many questions were referred to that Committee and they gave very valuable advice, but I could see that there was a great deal of jealousy on the part of those who were the military members of the Council of India of the interference, as it was said, of this Sanitary Committee. The military members said, "We "are the people who are responsible for the spending "of the money and for doing what is to be done, we "do not see why those gentlemen, who have nothing "to do with that, are to dictate to us; and we will "not accept their suggestions." Then would come from the Sanitary Committee remonstrances, and they would say, "We have special knowledge of this sub-"ject; it is what we are paying attention to; and we "think it very wrong that you should not attend to "our suggestions, and that you should spoil what we "are doing." In the same way I remember there was a kind of jealousy between the Commission which was appointed for revising the laws of India, and the Judicial Department of the Indian Council. The Commission consisted of men of very great eminence in the legal profession, and they were devoting their attention to the codification of the law of India, and they were proceeding on high principles. Constantly cases would occur in which it was necessary, for political reasons, or for social reasons, to depart from the principles so laid down; and then there came a collision. One the one side, we were told by the Commission that it was very improper to alter their high scientific codification of the law, and, on the other hand, we were told that the people who were dictating in this sort of way on general principles did not see the practical difficulties that arose, and that they might produce a mutiny in India, or cause great discontent here and there. And so with regard to a Council of Science, I am sure that if you had an independent body of that sort to be referred to with any kind of authority, jealousies would arise.

Sir S.H.Northcote, Bart., C.B., M.P.

27 Nov. 1872

13,638. Do you think that difficulties would arise of a financial kind ?—Yes, I think that there would be various difficulties. In the first place, I do not understand how this body would be constituted. Of course, different plans are proposed, but I see it is generally said that it should be well paid. Now, if the members were to be well paid, they would feel it their duty to earn their money, and if they did that they would interfere a good deal, and if they were to interfere a good deal they would excite the jealousy of which I speak, and also they would probably make such large demands upon the public funds as would raise the Chancellor of the Exchequer's indignation, and then there would be a good deal of difficulty in getting what was necessary. It would be found that the estimates of the Department must somehow or other be cut down, and the first direction in which they would be cut down would be in those items of expenditure which were proposed by the external body. The Department would look after and support its own expenditure, but it would be very jealous of the expenditure which was imposed by a body which was acting *ab extra*.

13,639. (*Professor Stokes.*) I think that one plan which was suggested was that in case of the institution of such a council the members should be paid a certain fee according to their attendance, in which case the total remuneration would probably not be very great ; would there be the same objection to such a scheme as that ?—I think that if you had a council, that would be the best mode of remunerating it, but I do not know that it would be free from objection.

13,640. (*Chairman.*) Probably, if your scheme with regard to making use of the Royal Society, or any other scheme, were adopted, you would sooner or later feel it indispensable that the ministerial responsibility should not be weakened in any way ?—I think it is essential that you should maintain the principle of the responsibility of the head of a department for the work which is done as well as for the money which is expended.

13,641. And that he should not be able to throw any part of the responsibility upon his advisers ?—No, because you would never be able then to fix the responsibility anywhere.

13,642. You are aware that 1,000*l*. a year, which is commonly called the Government Grant, is placed annually at the disposal of the Royal Society; have you considered whether that amount could without objection be increased ?—I should think that it might be increased if a good plan were proposed for the expenditure of the money.

13,643. Have you had, in your experience, applications submitted to the Government for aid towards objects of a scientific character not actually connected with the administrative duties of any department, but for some scientific expedition or the like ?—Yes, at the India Office there were frequent applications of that kind.

13,644. Have the same difficulties occurred in knowing how to deal with those cases as with matters arising in the administration of the office ?—Of course they are not the same kind of difficulties. I do not think that the experience of the India Office is precisely similar to that of the Government offices in England, because there is greater liberty on the part of the Government of India in dealing with the funds that are at its disposal; and in those cases it was usual to take the opinion of the Government of India, and probably of experienced members of the council; but still there was a great want of principle in saying what should be done and what should not be done ; how far money should be spent for journies of discovery, and other matters of that sort, and what should be done for the promotion of the geological survey, or anything of that kind, with reference to which we should have been the better very often for getting advice from some authority.

13,645. Several of the witnesses have stated to the Commission that they feel that there is considerable uncertainty as to how applications of that kind will be dealt with ; have you anything to suggest upon that point ?—There can be no doubt that one Secretary of State would take quite a different view from another ; a great deal depends upon the individual.

13,646. In all such cases should you like to see it become the established practice for the Government to apply for advice to the Royal Society ?—Either to the Royal Society or to some other body. Possibly it might be the rule that in all cases of exploration they should apply to the Geographical Society.

13,647. (*Professor Huxley.*) There is one other point which has been suggested by some of the witnesses who have been before us with respect to the utility of a scientific council ; and that is this, that a scientific council, the reports of whose proceedings should be published, would be, to a certain extent, under the control of public opinion with regard to the recommendations that it made, and it has been suggested, upon that ground, that such a council would be preferable to the irresponsible advisers to whom the minister has now occasion to apply. What is your opinion upon that subject ?—I had intended to say that I do not like the present system of applying to irresponsible advisers, and that I should desire to see some more systematic mode of proceeding adopted.

13,648. Is there any other mode which occurs to you besides the establishment of a scientific council ?—As I have said, I should prefer using some council appointed *ab extra* and not by the Government.

13,649. You would prefer, for example, the existing Council of the Royal Society to a body newly formed *ad hoc ?*—Yes.

13,650. (*Chairman.*) Do I rightly understand your principal recommendation to be that the Government should go to the Royal Society, not necessarily to get advice from them on the points on which they want it, but to find out from them where they could get the advice that they require ?—Quite so.

13,651. (*Professor Huxley.*) Are you acquainted with the machinery of what is called the Government Grant Committee ?—No, I am not.

13,652. That committee is appointed by the Council of the Royal Society of members of its own body, and to those members are added other persons who do not for the time belong to the administration of the Royal Society, so that the Government Grant Committee forms a sort of scientific parliament of about 40 persons, representing all the different interests of science in the country. Would you think a body of that kind the sort of body which might be looked to for advice with advantage ?—I should think it might.

13,653. (*Sir J. P. Kay-Shuttleworth.*) I understood that your chief apprehension, in the constitution of a scientific council, is, that it may obtain an inconvenient authority, and that considerable friction might arise between it and the departments of administration ; but would not that be very greatly modified if the body, whether it were the Council of the Royal Society or any other body constituted with the more distinct intention of discharging the functions which are to be committed to it, had simply a consultative constitution, and discharged duties like those which you have suggested might be discharged by the Council of the Royal Society ?—I am afraid that after a time it would be said that that body was of no particular use, and that it would be rather disregarded ; and, unless it had some kind of authority, it could hardly be maintained.

13,654. There are institutions of a scientific character already more or less connected with the Government. For example, there is the Meteorological Committee, which co-operates with the Board of Trade, and there is likewise the Royal Observatory ; and it has been suggested to this Commission that more observatories should exist, and that their capacities of action should be enlarged ; and it has been also suggested that the functions discharged by the British Museum should be enlarged, and the same also with regard to the Department at Kew. In relation to all those institutions, the Government at present has no advice but that which it seeks, and it is under the difficulty of being for the most part constituted of men who have not had a scientific education ; would there not be some advantage derived from having a permanently constituted

Sir S. H. Northcote, Bart., C.B., M.P.

27 Nov. 1872.

council, to which the Government in its several departments could go for advice in relation to the government of these several institutions?—I doubt whether such a council would either command public confidence very long, or command the respect which it should have from the Government itself, if it were a creation of the Government. You might appoint in the first instance some very eminent men. Probably you would not get a great many of the most eminent men to give a great deal of time to work of that sort, and you would have to take those who were willing to spare the time necessary for the discharge of the duties of the council. They would continue for some time in office, and they would adopt certain ideas, and their constant contact with the Government would rather lead them to say, "This sort of thing cannot be done," because they would take into consideration administrative points, and would not give purely scientific advice. They would, therefore, cease to possess the confidence of the public outside. There would also be more eminent men who would say, "These are old women who are going on in a certain "routine, and we do not attach much value to what "they say." And, on the other hand, they would not have the same advantageous independent position for offering advice or making suggestions to the Government which a body recruited *ab extra* from the scientific world would have.

13,655. But if the Council of the Royal Society had to administer a considerably increased grant, and if it had to fulfil the functions of advice described by yourself with respect to the appointment of individual investigators for the aid of particular Departments of the Government, and it likewise had some relation to the institutions to which I have already adverted, it would be loaded with an amount of work which would scarcely be consistent with its present independent and voluntary origin; would it not, in that case, be desirable to give it some more permanent constitution?—I dare say it might, but that is a point which I have not considered. I have no plan of my own upon the subject.

13,656. It has been suggested to the Commission that there might be connected with the Ministry of Education, if it should be founded, some council of scientific advice with respect to all the Departments of Scientific Education, and which might likewise discharge some of those functions, being controlled by the Minister of Education; would that relieve any of the difficulties which you apprehend?—I think that it would be very desirable that the Council of Education, or the Minister of Education, should have the advice of good scientific persons to assist him in directing the scientific education of the country; but I should doubt its being very advantageous to mix up that work with the other kind of duties to which you have referred.

13,657. (*Chairman.*) Do any other points occur to you on which you would desire to give us the benefit of your opinion?—I do not think that any other points occur to me.

Adjourned *sine die.*

No. 6, Old Palace Yard, Westminster, Tuesday, 11th March 1873.

PRESENT:

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART., IN THE CHAIR.

WILLIAM SHARPEY, ESQ., M.D., F.R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., SEC. R.S.
HENRY JOHN STEPHEN SMITH, ESQ., M.A., LL.D., F.R.S.

The Reverend THOMAS FOWLER, M.A., examined.

Rev. T. Fowler, M.A.

11 March 1873.

13,658. (*Chairman.*) I believe you are a Fellow and Tutor of Lincoln College, Oxford?—Yes.

13,659. Will you be good enough to state to us upon what forms of teaching in the University you wish to remark?—First of all, there is professorial teaching, which is given by University professors or readers; secondly, there is tutorial teaching, which is given by the tutors or lecturers of the Colleges; and thirdly, there is private teaching, which is given by private tutors.

13,660. What is the relation of the professorial to the tutorial teaching? The most general distinction, is, perhaps, that the professorial teaching is on subjects rather than on books, whereas the tutorial teaching is on books rather than on subjects. But that is by no means universally the case; very often the tutorial teaching is perfectly indistinguishable from the professorial teaching, and occasionally the professorial teaching is on books rather than on subjects.

13,661. A system of combined College lectures has arisen. Does that affect the definition of the limits between the tutorial and the professorial teaching? Yes, to a very great extent. Several of the lectures given under the combined system of lectures are really professorial.

13,662. Although they are given by tutors? Yes; that is to say they are given to large classes, and they are frequently on the more general aspects of the subjects, and, as a rule, they require far more preparation than the old-fashioned College lectures used to require. I have brought a copy of the "Oxford University Gazette," which contains the subjects of professors' lectures for this term, and also some of the schemes of combined College lectures.

13,663. Could you enumerate conveniently the subjects of the combined lectures?—As an illustration of what I say with regard to lecturing upon subjects, I find that in the Literæ Humaniores School, which is the school with which I am principally acquainted, there is a lecture upon the History of Greek Philosophy, which, in old times, would have been thought rather to be a subject for a professor's lecture. Then there are lectures on Roman History—not on particular books connected with Roman History—but on special departments of the subject. Again, I find in the combined lectures given by the Mathematical Tutors (and I see Professor Smith lectures in that course, although he is a Professor), that there are several subjects which would not have been taught by College tutors when I was myself an undergraduate. Perhaps what I say applies still more to the combined lectures given by the modern history teachers. I will leave this "Gazette" with the Commission (*handing in the same*).*

---

* COMBINED COLLEGE LECTURES.

I. LITERÆ HUMANIORES.

† Plato's Republic, Book V.	Mr. Fowler (Lincoln).	Monday, Wednesday, and Friday, at 10.
Plato's Protag. Gorg. and Phaedr	Mr. Monro (Oriel).	Monday, Wednesday, and Friday, at 10.
Plato's Republic, Book I.	Mr. Moore (Queen's).	Monday, Wednesday, and Friday, at 10.

† Continued from last Term

13,664. The attempt to organize the College lectures with reference to University lectures is chiefly confined to the subjects of mathematics and modern history, is it not?—I would rather put it in this way. There has been very little attempt to organize the College lectures with reference to the Professorial

---

[a] Roman History, from the end of the Third Punic War.	Mr. Grose (Queen's).	Monday, Wednesday, and Friday, at 11.
Roman History, from the Decemvirate.	Mr. Creighton (Merton).	Wednesday and Friday, at 11.
Novum Organum.	Mr. Wallace (Merton).	Monday, at 11.
[a] Greek History, with Aristotle's Politics.	Mr. Dill (C.C.C.).	Monday, Wednesday, and Friday, at 12.
Aristotle's Ethics, Books I. VI. X.	Mr. Pater (B.N.C.).	Monday, Wednesday, and Friday, at 12.
[a] Aristotle's Ethics.	Mr. Illingworth (Jesus) (for Mr. Thursfield).	Tuesday, Thursday, and Saturday, at 10.
Aristotles Ethics, Book I.	Mr. Magrath (Queen's).	Tuesday, Thursday, and Saturday, at 10.
Aristotle's Ethics.	Mr. Pater (B.N.C.).	Tuesday, Thursday, and Saturday, at 12.
History of Greek Philosophy.	Mr. Wallace (Merton).	Tuesday, Thursday, and Saturday, at 12.
[b] The Moral Systems of Shaftesbury, Hutcheson, Butler, and Hume.	Mr. Fowler (Lincoln).	Tuesday and Saturday, at 1.

2. MATHEMATICS.

Higher Algebra (Determinants and Theory of Numbers).	Prof. H. J. S. Smith (Balliol).	Tuesday and Thursday, at 9.
Analytical Geometry (Modern Methods, &c.).	C. J. C. Price (Exeter).	Wednesday and Friday, at 9.
Differential Calculus (Geometrical Applications).	C. J. Faulkner (University).	Wednesday and Friday, at 10.
Integral Calculus (Higher Course).	Prof. H. J. S. Smith (Balliol).	Thursday and Saturday, at 11.
Dynamics of a Particle.	G. Edmundson (Brasenose).	Tuesday and Thursday, at 9.
Rigid Dynamics.	W. Chadwick (Corpus Christi).	Wednesday and Friday, at 10.
Optics.	C. J. Faulkner (University).	Tuesday and Thursday, at 12.
Problems in Pure Mathematics.	W. Esson (Merton).	Monday and Wednesday, at 11.
Problems in Mixed Mathematics.	W. Chadwick (Corpus Christi).	Tuesday and Thursday, at 10.

These Lectures will be open to gentlemen belonging to the Colleges of which the above-mentioned gentlemen are Lecturers. Gentlemen not belonging to these Colleges and wishing to attend any of the Lectures, may do so, with the consent of their College Tutors, upon payment of a fee of 1*l.* for each course.

3. MODERN HISTORY.—LECTURES WILL BEGIN ON WEDNESDAY, JANUARY 29.

Mr. Boase will lecture at Exeter on—

English History, from Henry III., on Tuesday and Thursday, at 10

English History, from William III., on Wednesday and Friday, at 10.

Mr. Owen will lecture at Christ Church on—

The Reign of George III., on Monday and Wednesday, at 11.

The British Conquest of Southern India (continued), on Saturday, at 12.

Mr. Kitchin will lecture at Christ Church on—

European History from 1763, on Tuesday and Thursday, at 12.

The Papacy during the Sixteenth Century, on Monday and Friday, at 12.

Mr. Bright will lecture at University on—

European History from 1648, on Thursday and Saturday, at 10.

At Balliol on

English History (England after Catholic Reaction) from Mary to the Rebellion, on Thursday and Saturday, at 12.

At New College on—

The Distinctive Features of English History, on Friday, at 10.

Mr. George will lecture at New College on—

The History of the Papacy and Western Europe, from 476, on Tuesday and Saturday, at 10.

Political Science, on Wednesday, at 12.

International Law, on Monday and Wednesday, at 10. (For gentlemen intending to offer it instead of a Special Subject in the History School, or for those beginning it for the Law School.)

Mr. Laing will lecture at Balliol on—

English History, from Richard I., on Monday and Wednesday, at 11.

At Wadham on—

The Distinctive Features of French History from the Earliest Times to the Eve of the Revolution, on Tuesday and Thursday, at 11.

Mr. Creighton will lecture at Merton on—

Italy during the Renaissance, on Tuesday and Saturday, at 10.

The German Reformation, from 1535, on Thursday, at 10.

Mr. Knox will lecture at St. John's on—

The English Reformation (continued), on Monday and Friday, at 12.

These Lectures will be open to all Members of the following Colleges:—University, Balliol, Merton, Exeter, Oriel, Queen's, New College, Lincoln, Magdalen, Corpus, Christ Church, Trinity, St. John's, Wadham, St. Mary Hall, and to all other persons by special arrangement with the Lecturer.

4. NATURAL SCIENCE.—MERTON, MAGDALEN, AND JESUS COLLEGES.

Mr. Wyndham will give a Course of Lectures on the "Minerals which are of importance as the Constituents of Rocks."

This course is one of a series which will include "The Minerals which are of importance as Ores of the Metals and Sources of Chemical Products," "The Minerals of Coal and Saline Deposits," &c. &c., and is intende for students engaged in the study of Chemistry and Geology.

Time—Tuesdays and Saturdays, at 9 a.m.

Course begins Saturday, February 1.

Place—Magdalen College Laboratory.

The course will be in connection with a practical class for the recognition of the Minerals mentioned in the Lecture, to be held in the Mineralogical Laboratory, University Museum.

Further notice of this will be given.

Mr. Chapman will continue his Lectures on "The Outlines of Zoological Classification."

Place—Magdalen College Laboratory.

Time—To be arranged.

5. THEOLOGY.

Psalms 33–72, Hebrew Text and Septuagint Version.	Mr. Deane (St. John's).	Monday, Wednesday, Friday, at 12.
Prayer Book (Part II.) and Ancient Liturgies.	Mr. Ince (Exeter).	Tuesday, Thursday, at 10.
The Subject-matter of Exodus.	Mr. Hanbury (Wadham).	Tuesday, Thursday, at 11.
Introduction to the Gospels (Part II.).	Mr. Jayne (Jesus).	Monday, Friday, at 10.
St. Paul's Epistles to the Ephesians, Philippians, &c.	Mr. Mylne (Keble).	Monday, Friday, at 12.
Pearson on the Creed, Articles III., IV., V.	Mr. Mylne (Keble).	Wednesday, Saturday, at 10.
Irenaeus adv. Haer. III. (Text).	Mr. Wordsworth (Brasenose).	Thursday, Saturday, at 12.
Textual Criticism.	Mr. Hammond (Exeter).	Tuesday, Thursday, at 11.

Those who are not members of the Colleges to which the Lecturers belong may be admitted to the Lectures on payment of 1*l.* for each course.

The Lectures will be begin on Wednesday, January 29. Those who wish to attend are desired to call between 1 and 2.30 p.m., on Tuesday, January 28.—(*Oxford University Gazette for January* 24, 1873.)

---

[a] Continued from last Term.

The Philosophical Lectures on this List are open to members of Merton, Oriel, Queen's, Lincoln, Brasenose, and Jesus Colleges, and the Historical Lectures to members of the above Colleges, and also of Corpus. The Lectures are also open to other members of the University by special arrangement with their Tutors. The Lecture marked *b* is open to all members of the University.

Rev. T. Fowler, M.A.

11 March 1873.

lectures, or the Professorial lectures with reference to the College lectures, except in the departments of mathematics and modern history.

13,665. Do you think such an organisation desirable?—I think it very desirable, indeed, if it could be attained.

13,666. Is there any likelihood of its being carried out?—I should be afraid there is not much likelihood of its being carried out, unless some considerable changes are made in the character of the Professoriate.

13,667. What are the grounds upon which you think it desirable that professorial teaching should be largely extended?—I think there would be much more thorough study of the subjects on the part of the Undergraduates. I also think that we should produce a much larger proportion of students amongst the Graduates themselves. I can see no way of promoting mature study in the University except by an increase of the Professoriate.

13,668. What steps would you take for the accomplishment of those objects?—I should not very largely increase the number of Professors, or what, perhaps, I may call Principal Professors, though certainly it would be necessary to do so in some subjects, especially, I think, in the subject of Natural Science; but I should add to the present body of Professors a new class, who might be called, with reference to the existing Professors, Assistant Professors, or, if they were called professors, the present professors might be called Principal Professors. I think, if that were done, the Principal Professors might be relieved from a large amount of teaching, though I would still require a certain amount from them, and that the ordinary teaching in all the higher departments of study might be undertaken by the Assistant Professors; that is to say, I would transfer to the Assistant Professors some of the duties now performed by the Professors, and also some of the duties now performed by the College Tutors.

13,669. Do you see a sphere of action for any other class of Professors?—Yes; I should contemplate all the Professors of whom I have spoken, whether Principal Professors or Assistant Professors, as being resident in the University, and taking a considerable part in the instruction of the Undergraduates. But I think, in addition to the resident professors, there might very usefully be instituted a class of Professors on whom there should be no obligation of residence. I should expect these Professors to deliver a certain number of lectures in the course of the year, and I should be inclined to make their professorships terminable. It would then be possible to bring up to the University, from time to time, some of the more eminent men in each department of science or literature, who would, I think, add life to the studies of the place, and who would occasionally produce books which might give a great impetus to the study of their subject, or throw great light upon it. An additional reason for instituting such a class of Professors is, that I do not think the University is likely, even after the redistribution of its revenues, to be able to give such large stipends to its Professors as to tempt men of first-rate ability, who have a sphere before them in London, to come and reside permanently in Oxford. But, by having professorships of some 300*l.* or 400*l.* a year, the only requirement being a certain number of lectures, we might hope to attract for short periods the most eminent men in the country. In fact, we do a little in this direction at present. Mr. Ruskin is now lecturing in Oxford as holding a terminable professorship of the kind I describe. Sir Henry Maine, though holding a permanent professorship, is practically, I believe, relieved from residence, and is required to give only a small number of lectures. Now, in the case of both these gentlemen, I presume it would have been impossible to secure their services had the University insisted, as it does in the case of its ordinary Professors, on a six months' residence in the year, and on stringent regulations with regard to the number of lectures to be delivered.

13,670. (*Professor Huxley.*) Will you kindly say whether you would propose to assign to the Assistant Professors, whom you mentioned, the duties which are commonly performed by demonstrators in teaching physical science?—I speak with a certain amount of ignorance with regard to physical science, but, so far as I understand the question, I should certainly say yes.

13,671. That is to say, you would make their teaching personal to the students?—Yes.

13,672. And demonstrative upon the apparatus?—Yes.

13,673. (*Dr. Sharpey.*)—Then, perhaps, you will state explicitly what you conceive would be left for the Principal Professors to do?—To deliver a certain number of lectures in the course of the year.

13,674. Upon what?—Upon either the general aspects of the subject, or upon some branch of the subject carried beyond the point to which it could be studied in ordinary books. In fact, I should regard the Principal Professors as being the persons who were advancing learning and science, whereas the Assistant Professors would be mainly engaged in teaching the better class of Undergraduates, that is to say, the Undergraduates who go up for honours.

13,675. The Assistant Professor who would, generally speaking, correspond to a demonstrator in physical science, would set free the Professor, so as to enable him to devote his energy to something higher?—Yes. Perhaps you will allow me to say that I think there would be another great advantage in the scheme which I propose. At present there is hardly any chance of promotion in Oxford. And what I think is essential, if we are to retain our best men in the University, is to have some hierarchy of offices through which a man might gradually pass, giving him some hopes for the future.

13,676. (*Chairman.*) Will you be good enough to describe what you consider to be the obstacles to Collegiate teaching at present?—The great obstacle I think is the smallness of the Colleges, and, I may add, in many cases their isolation. There are at present in Oxford 19 of the older Colleges, Keble College, and five public Halls, besides one or two private Halls, that is to say, there are 26 or 27 distinct centres of instruction. These Colleges and Halls are of very various sizes, some of them containing upwards of 200 Undergraduates, and others, I believe, not containing 30. Until within my own recollection each of these Colleges and Halls attempted to give an entire course of instruction to its Undergraduates, and that tradition still lingers on to a great extent. It is quite obvious, I think, that the instruction given by societies so small as some of these are, must, unless they seek assistance from outside, be really of an exceedingly elementary, and very often of an extremely unsatisfactory character.

13,677. Does this operate in a special manner as a discouragement to the newer and less popular subjects of study?—Certainly; because even in the largest Colleges it is exceedingly difficult to find teaching in every branch of study encouraged by the University, and in the smaller Colleges and Halls it is absolutely impossible.

13,678. The schemes of combined lectures have been chiefly brought about by a desire to overcome these difficulties?—Yes.

13,679. Will you state your opinion of the effect of them?—I think the effect has been very beneficial, but I regard the combined lectures as merely a transition to something better. When two or three Colleges combine to give instruction, either generally or in some special branch of study, it is plain that the Tutors can devote themselves more exclusively to those branches which they are most competent to teach, and that the Undergraduates will have better teaching from the best tutor on each subject in a group of two or three Colleges than from the best tutor on each subject in his own College. I also attach great importance to several men being brought together in the same lecture. I recollect the time when many of the lectures did not consist of more than three or four

Rev. T. Fowler, M.A.

11 March 1873.

Undergraduates, and of course it was very difficult for a tutor to put forth his best powers under such circumstances. At present, when a man lectures to 20 or 25 Undergraduates, he is certain to take pains in preparing his lectures, and will probably be on his mettle while delivering them.

13,680. Can you state what number or proportion of the Colleges are included in these combinations?—There are various combinations. The most complete one existing at present, I believe, is that between Balliol, New College, and University College. Lincoln and Oriel Colleges are contemplating a still more complete union. At present, in the subject of Literæ Humaniores for the final classical schools there is an union between Merton, Oriel, Queen's, Lincoln, Brasenose, and Jesus Colleges. In the subject of modern history there is an union between no less than 14 Colleges and one Hall. I may also add, that a system has grown up by which tutors, without any formal union of lectures, exchange pupils, so that if there are only two or three Undergraduates in a College reading one subject they are sent to the tutor of another College who has a larger class.

13,681. You regard the work at present being done as a step towards some other arrangement?—Yes, certainly. In most cases there is no definite arrangement between the Colleges as to payment, nor is there any satisfactory plan of organising the lectures. Moreover, many of the tutors who lecture in these schemes have a number of miscellaneous duties which it is difficult to unite with the *quasi* professorial teaching which they give to the groups of Colleges.

13,682. The principle which is involved in this voluntary organisation of combining Colleges for the purposes of teaching would extend to a central University system?—I think a very large proportion of what is done by these combined schemes of lectures would be much better done by the University, if the University had a sufficient staff.

13,683. Supposing that there were that staff, and that the organisation were completed, and were placed under some Board of Studies or other central authority, there would still be occasion for lectures to small classes, would there not?—I think so. I think our present system of combined College lectures is somewhat defective, from not being supplemented by catechetical lectures. It is impossible, however, in many cases, for a tutor to find time, both for lectures to large classes and for catechetical lectures.

13,684. Besides which there would remain the private assistance and advice to be given to students in private?—Yes, and that I think of great importance. I regard it as being of great importance that each student should be put in an official relation to some tutor to whom he can go in cases of difficulty, and from whom he can receive advice.

13,685. If the organisation were completed, and the whole of the Colleges were thus co-ordinated with a Board of Studies or other central authority, the professorial teaching might be supplemented by that given by the Tutors?—Yes.

13,686. The work of the one might be appropriately combined with the work of the other?—Yes.

13,687. The tutorial teaching might be a means of testing a student with regard to the work done by the professor?—Yes. I think that the tutors would have an important function in testing the instruction given both by the Professors and by the Assistant Professors.

13,688. But even for the present arrangements, do you consider that the College unit is a satisfactory basis?—I think that the College unit ought to be a larger one than it is at present. I am not prepared to say that there are not one or two Colleges in Oxford sufficiently large, but it would be a great advantage, I think, to group, more or less intimately, some of the smaller Colleges and Halls.

13,689. So that even for the assistance of students in their studies, and the strictly tutorial work, you would desire to form larger aggregates than those which now exist in the Colleges?—Certainly. Perhaps I may illustrate what I mean. I will take a College having 60 or 80 Undergraduates; there are several Colleges of about that size. In such a College, at the present time, there will probably be only two or three men reading natural science; perhaps, only five or six reading modern history, ten or a dozen reading for honours in the final classical schools, and so on. Now it is very difficult to provide even advice for those students who are reading the less popular subjects, and, of course, to provide College instruction for them, except by a system of combination, is absolutely impossible.

13,690. You would organise the matter so that the Tutors of a College or a group of Colleges should, as a rule, lecture in subordination to the Professors and Assistant Professors of the University?—Yes, as far as that could be done, but I think it would be quite impossible to lay down a definite rule upon that subject. There are many circumstances in Oxford which would render such a rule so odious that it would be found practically impossible to carry it into effect. I have no doubt, however, that if we had a really efficient Professorial staff in each subject, the College Tutors would be only too glad in most cases to lecture in subordination to it. To give one reason only for the impossibility of laying down definite rules as to the subordination of lectures, even supposing that you were to draft, from time to time, the most efficient Tutors into the Professoriate, there would still spring up other Tutors taking a prominent position in the University, and it would be very difficult to induce them to undertake only the subordinate branches of a subject when probably they felt, and their friends felt, that they were quite as competent to lecture upon the higher branches of the subject as the Professor or Assistant Professor. As a rule, however, I think that the younger men (and that the College Tutors would generally be) would be only too glad to lecture on the less difficult branches of the subject and leave the more difficult or more important branches to the Professoriate.

13,691. You have no doubt reflected upon the nature of any governing bodies which should have authority for the co-ordination of the Colleges and the regulation of the relations between the Professors, the Assistant Professors, and the Tutors?—I have reflected on it:—I think that is one of the great difficulties which we have to encounter. But I should expect much from voluntary organisation. I think, if the Professors, the Assistant Professors, and the College Tutors were to meet at the beginning of Term, there would practically be little difficulty in drawing up a common lecture list. We are so accustomed to act together in Oxford that I should be very sanguine that the difficulties would disappear if the matter were left to voluntary action. On the other hand, any compulsory organisation would provoke a good deal of resentment.

13,692. Out of this discussion and this voluntary arrangement there would come ultimately to be some form which would be recognised as the ordinary mode of action?—I think so.

13,693. Do you anticipate any advantage in economy by the arrangement of a fusion of Colleges?—Yes, considerable economy would be effected by the fusion of some of the smaller Colleges, and the amount would, of course, depend very much upon the extent of the fusion. If you could actually unite the Corporations of two small Colleges you would require, for instance, only one Head, only one Dean, and only one Bursar, and it would also effect a large saving in the staff of College servants.

13,694. What are the obstacles to a fusion of the Colleges?—In the present state of Oxford, I think there are few obstacles to a fusion of the educational staff of some of the Colleges, but to the fusion of the Corporations there are certainly very considerable obstacles. Each College has its traditions, its history, and its peculiar associations, and many members of the College would probably be loth to merge these in some common foundation. It ap-

Rev. T. Fowler, M.A.

11 March 1873.

pears to me that the advantages to be gained by a complete fusion in certain cases are so great that I should be willing to sacrifice the counter advantages which I have named, though, at the same time, I quite appreciate their importance.

13,695. Are your own feelings and opinions upon this matter participated by any considerable proportion of the Fellows of small Colleges?—I should hardly say a considerable proportion, but there are a good many who share my views.

13,696. The progress of discussion tends to bring out the advantages of the fusion and to diminish the repugnance which is felt towards it?—I think so. I must add, however, that I do not suppose that the proposal has been widely discussed in Oxford. It would, probably, be quite new to many members of the University.

13,697. What do you think has been the tendency, in the course of your experience, as respects the separate Collegiate action, as contrasted with the development of the power and authority of the University?—When I first came up to Oxford, which was about 22 or 23 years ago, an Undergraduate rarely looked for instruction beyond his own College. A College undertook to give instruction in classics, mathematics, ancient history, and ancient philosophy, and very few Undergraduates studied any other subjects. The only Professors resorted to, as a rule, were one or two of the Professors in Physical Science and the Professors in the philosophical subjects. Since that time there has been a gradual tendency, on the part of the Undergraduate, to look more to the University for teaching and less to his College. The College Tutors have, of recent years, encouraged this tendency, but I recollect the time when, in many Colleges, students would have been refused permission to absent themselves from a College lecture in order to attend an University lecture. Perhaps, I should also add that the Professorial teaching now has more reference to the subjects of examination than it had at the time when I was an Undergraduate.

13,698. The Professorial is now in more perfect harmony with the Tutorial teaching of the Colleges?—Yes, there is a closer approximation between the two.

13,699. These phenomena may be regarded as steps towards that organisation of the University and the Colleges which you would consider most desirable?—Yes.

13,700. You have described the range of studies as having been, in the early part of your experience, narrow; has there been any enlargement of that range of study, and what has been the effect of that upon the relation of the University to the Collegiate teaching? By the establishment of new schools (by which I mean schools of examination), the University curriculum has been much extended. It has become, therefore, more and more impossible for Colleges to supply the requisite amount of tuition, and the students have consequently been driven from the College to the University, in order to obtain efficient instruction in many of the subjects which are least commonly pursued. This has also led to the University lectures being more generally frequented, even in the subjects which are most popular.

13,701. (*Professor Huxley.*) What will be left for the Tutors (I refer now especially to physical science), when the Assistant Professors are appointed in the numbers which you contemplate?—They would give assistance and advice. There would remain, too, the setting of questions, from time to time, in the subjects of study, and small catechetical lectures, all of which, I think, are of great importance. If you will allow me to take the case of a student, and consider what the student requires, and how he is to have his requirements satisfied, I think I shall be able to bring out my meaning. I should prefer taking some subject I am acquainted with.

13,702. Let us, then, take the case of either philosophy or ancient history, as you think best? Either will serve the purpose. I will take the case of a student reading either philosophy or ancient history. I think he ought to attend lectures in certain books, say such books as the Ethics of Aristotle, or Thucydides, or Locke. These lectures would be given by the Assistant Professors. Besides the lecture of the Assistant Professor, I think he should occasionally, say about once a week, go to a small catechetical lecture, in which he might put difficulties before the lecturer, and in which he might be examined as to the knowledge he had acquired by attending the lectures of the Assistant Professor. That work I think could be very well done by a man younger than the Assistant Professor, who, according to my scheme, would be a College Tutor. The College Tutor would also, from time to time, set him questions to be answered in writing. That, I may remark, is now done to a great extent in Oxford, and it forms a very important part of our work. It should also be open to the student to take, from time to time, difficulties in his books to his Tutor, and to ask his Tutor's advice as to the books he should read, and the lectures to which he should go. Then, towards the end of the student's course, I think it would be of the greatest advantage to him to go to lectures, either in some special department of the subject on which the Assistant Professor would not have sufficient time or sufficient knowledge to lecture, or on the general aspects of the subject. At that point the Professor's functions come in. The student would, in that way, be brought into contact with a man of mature age and considerable research, and, possibly, of considerable original power, and would acquire a view of his subject, and of the proper method of handling it, which could not well be derived from a mere lecturer on a book, however good.

13,703. I gather that your plan, as regards philosophy, would correspond as nearly as possible with the best methods of teaching physical science. For example—if I wished to teach a student biology, I should like to set him to work to dissect some particular animal, under the guidance of a Demonstrator: that would answer to your lecture by an Assistant Professor?—Yes.

13,704. In the next place I should like him to be more or less under the care of a "Répétiteur," as the French call it, who would examine him, and who would give him subsidiary instruction upon that work?—Exactly.

13,705. Thirdly, I should like him to have access to the lectures of a Professor-in-chief who would give him broad views also. Therefore, the two methods quite correspond?—Yes. It seems to me quite essential that there should be these three classes of teaching, and that there should be special persons appointed for each.

13,706. There is no doubt that that is the most approved method for physical science teaching?—And I think for all teaching. I should attach the greatest importance to each of these three classes of teaching being properly provided for in the University or the Colleges.

12,707. You are doubtless aware that in the best schools of physical science these three classes of teaching are established?—Yes, I was aware of that. I may say that these three classes of teaching are to some extent already provided for at Oxford, but it is done in an unsystematic way, and unequally in the different Colleges.

13,708. (*Professor Smith.*) I think you referred to private tuition as one of the three kinds of teaching that are given in the University?—Yes.

13,709. I should like to ask whether you consider that private tuition is on the increase or on the decrease in the University?—Very much on the decrease, and I refer that circumstance mainly to the introduction of combined College lectures. The system of combination leaves the Tutors more at liberty to give private advice and instruction, and it also provides far better lectures than used to exist under the old system. In my own College I have difficulty in recalling more than two or three cases within the last seven or eight years during which our students for

Rev. T. Fowler, M.A.

11 March 1873.

honours in moderations or in the final classical schools have had resort to a private Tutor.

13,710. Is the same the case with private tuition in the case of men who are not candidates for honours. I am not speaking of your own College merely, but of the whole University ?—No. Private tuition obtains to a much greater extent in the pass subjects than in the honours subjects.

13,711. With regard to pass men, are you of opinion that the system of private tuition is also upon the decline in the University generally ?—I do not know so much about pass-men as about class-men, but I imagine it is also upon the decline in their case. I speak with a little reserve, however, with reference to pass-men.

13,712. Have you any wish to see the system of private tuition revived in connection with the reading for honours ?—No, though, at the same time, I think that under any University system there would be some room for private tuition. It appears to me that a man may, from various causes, be behind the rest of his class, or may be obliged to prepare his work within a shorter period than his fellow students : and, in these cases, it is desirable that he should have more private tuition than a College Tutor can, in justice to the rest of his pupils, afford him. There are some men also who learn much more from a *tête-à-tête* conversation than from attending lectures, though I think that our present system of tuition tends more and more to make these cases rare.

13,713. So that, within a certain limited range, you do think that there is still a scope for private tuition in the University ?—Yes, but I think the private tuition should be the exception rather than the rule. I recollect the time when it was the rule in Oxford, and this state of things was attended with great evils.

13,714. Passing, then, to the three classes of teachers whose duties you have so clearly defined—the College Tutor, the Assistant Professor, and the Professor—I think I understand you to admit that there would be considerable difficulty in organising, in any formal and compulsory manner, the instruction given by those different classes of teachers ?—Yes, I think there would be, and mainly for the reason I assigned, that men are not differentiated by such broad lines of difference as to render it possible to assign the higher branches of instruction to one man and the lower to another by any strict rule. There must, of course, also constantly occur cases in which the Professor is inferior to some of the other teachers upon the same subject within the University, or at least not more than their equal. In those cases considerable hardship would be inflicted upon the students if they were only allowed to hear lectures upon the more important or difficult branches of the subject from the Professor-in-chief. It might, in certain cases, amount to a prohibition placed upon the teaching of the more important branches of study in any given subject.

13,715. You have spoken in connection with these three classes of officers of the great importance of there being a kind of, I think you used the word, hierarchy, a kind of succession of offices, so that there might be some opportunity of promotion within the place ? —Yes.

13,716. I wish to direct your attention to a difficulty connected with that which would arise from rendering your highest places, that is to say, your principal professorships, places of reward, and your appearing in any way to limit them to being rewards for teaching services rendered in a lower position ?—Yes, I am quite aware of that difficulty, and I think it is most important that the principal professorships should not be confined to the Assistant Professors, that is to say, that there should be no right of succession, though, at the same time, I should anticipate that in the majority of cases an Assistant Professor would be selected. The third class of Professors which I have proposed would give the University an opportunity of acquiring the services of the most eminent men throughout the country. Except in rare cases, I think that if strict residence were insisted upon, as would be necessary in the case of ordinary Professors, the University would not offer sufficient attraction for eminent persons who had not been previously associated with its teaching. My meaning is this. Suppose you have two professorships, we will say in physiology, the one endowed with 1,000*l.* a year, and the other with 400*l.* or 500*l.*, the one involving residence and the other not, I should hardly hope to secure the services of the most eminent physiologist in the country for the resident professorship, though I should have great hopes of securing them for the non-resident professorship. The result of that would be that the resident professorship would probably fall to the lot of some man who had distinguished himself as an Assistant Professor ; still it is most important of course that it should be open to the University to secure the services of the most eminent man in the subject if he would accept the office.

13,717. (*Chairman.*) On the other hand, there is the collateral advantage that if the good service of an eminent man as Assistant Professor were regarded in such a case as the legitimate mode of approaching a professorship, you would get better men for your Assistant Professors ?— Yes, but I should think it most undesirable to limit the professorship to the Assistant Professors.

13,718. (*Professor Smith.*) We have found the term "Assistant Professor" a somewhat ambiguous one, from its not really explaining, upon the face of it, what amount of subordination to the Principal Professors is implied by the term ?—Instead of speaking of Assistant Professors and Professors, I should prefer to use the words "Professors" and "Professors-in-chief," or "Principal Professors." I would say, in explanation of this proposal, that there are many men who would attach a great value to the title of Professor, from the position it would give them in foreign countries, or in general society in England, and I should contemplate the Assistant Professors being persons of sufficient mark to render them worthy of such a title. I would indicate the subordination rather by giving some distinguishing title to the Principal Professors than by giving some title implying inferiority to the Assistant Professors.

13,719. (*Professor Huxley.*) If the Assistant Professors, if I may so call them, were persons of sufficient distinction, would it not be exceedingly difficult for the University to pass them over in case of a vacancy in a principal professorship ?—I think not, if there were some person of much greater eminence outside. This has constantly happened in Oxford. It has constantly occurred that a man has been doing the work of a chair for some time, and that, although very efficient, he has been passed over in favour of some other person.

13,720. (*Professor Smith.*) While the position of the Assistant Professor, or, as you would prefer to call him the Professor, as compared with the Principal Professor, would be one of a certain amount of subordination, you would wish to leave a large independence to the Assistant Professor ?—Yes.

13,721. With reference to the appointment of the Assistant Professors, as it is evident that the mode of appointment would be of the greatest importance, have you considered any way in which you would wish to see that done ?—I think it would be very important to give the Professor a powerful voice. I am not quite sure that I should not give him a veto upon the appointment. I have hardly made up my mind as to that, but certainly I should give him a very important position in the Board of Electors.

13,722. (*Chairman.*) There would be such a need for co-operation between the two classes of Professors, and for the influence of the Professor, descending, as it were, through the Adjoint Professor to the tutorial department of the Colleges, that it would be extremely important that the link should have the sanction of the Principal Professor ?—Yes, I think so, and I think the harmony between the two would be secured to a great extent by giving the Professor an important voice in the appointment of the Assistant Professor. The

Rev. T. Fowler, M.A.

11 March 1873.

difficulty, however, with regard to the appointment of the Professor is, I may say, the greatest difficulty connected with this subject.

13,723. (*Professor Smith.*) As you have expressed your sense of the great importance of having a proper mode of appointing Professors, we should be very glad to hear your views upon that subject?—I should attach great importance to a variety in the mode of appointment. I think it would be a great misfortune if all the Professors, or any large proportion of them, were appointed by the same board, or by boards possessing any very close analogy.

13,724. What is the danger which you would apprehend from that?—The danger which I should apprehend would be that appointments would fall into the hands of a clique, and that there would be too much scope for personal or professional jealousy.

13,725. And also you would feel, would you not, that it would be, according to the vulgar phrase, "putting too many eggs into one basket?"—Yes, risking too much in one boat.

13,726. Have you considered the possibility of this plan: if there were a larger Board of Studies in any particular Faculty, or if there were a board formed that had the direction of the Studies in any particular Faculty, has it occurred to you that it might be possible for such a board, say, to nominate beforehand electors *ad hoc* to fill up any vacant professorship?—That has not occurred to me, but I think that it might be one good way of constituting an elective body. I think a Board of Studies itself, in some cases, might not be a bad elective board. A third mode of election might be by boards constituted by Congregation, or rather by those members of that body who are engaged in tuition or instruction within the University or the Colleges.

13,727. I think you have already told us your views as to what I may venture, for the moment, to call the compulsory organisation of the instruction given by these various classes of teachers; but I should like to ask you whether, taking such a subject as philosophy, if you were to form within the University a Faculty of Philosophy, and if in that faculty, or if in the board directing that faculty, you were fairly to represent the Professors, the Assistant Professors, and the Tutors, and all parties concerned in that faculty, do you or do you not consider that it would be possible to organise the faculty in such a manner that they should be able to meet together at the beginning of each Term in an official instead of in an unofficial manner, and arrange the courses of instruction to be given during the Term, or during the year as the case might be?—I think it would be quite possible, but I do not think you could forbid any of those persons from giving a lecture on his own account.

12,728. You would not interfere with the academical liberty of prophesying which we at present possess?—No, I think the University gains very much from that.

13,729. But you do not see a difficulty in giving to this meeting, which must be held of persons interested in the study, an official character?—No, I think it would be a great advantage to give it that character; still I should be sorry to forbid any one of those teachers from giving lectures in addition to the lectures which appeared in the official list, if he thought good to do so.

13,730. You mentioned the subject of a possible future fusion of the Colleges?—Of the one or two points in connexion with that to which I should like to direct your attention, one is a strong local reason, if I may so call it, which exists for such a fusion in the case of some of the Colleges, owing to their being absolutely cramped for ground?—Yes.

13,731. Has this occurred to you as an important reason in favour of it?—It has. Moreover, some of the Colleges and Halls are so small or poor, that I think it will be very difficult, indeed, for them to prolong an independent existence when the larger and richer Colleges put forth their whole strength.

13,732. They would be crushed between the greater societies?—Yes.

13,733. (*Chairman.*) And your desire is rather to see these smaller Colleges combined than to see them absorbed in the large Colleges?—I do not think it makes much difference whether we speak of them as being combined or absorbed, but my argument is that there would be a large waste of public money in the event of some four or five of the smaller Colleges attempting to lead an independent existence and ceasing, as I think it is quite possible they might do, to perform any important academical functions. I think it is quite possible that some of the smaller Colleges might be almost completely deserted by Undergraduates, and in that case their revenues would be to a large extent thrown away.

13,734. (*Professor Smith.*) One reason evidently in favour of the fusion of Colleges would be, as you have pointed out to us, the economy of the public funds which would be attained?—Yes.

13,735. With reference to this question of economy in the fusion of Colleges, I wish to ask whether, unless some steps are taken to obviate it, there might not also be a loss in this way; at present, although it is admitted that the headships of the smaller Colleges are not perfectly utilized offices, yet there would not appear to be any very strong reason why they should not hereafter be rendered useful in connexion with the University. If, therefore, you were to diminish the number of those offices, there would be some danger of your sustaining a loss?—I should much prefer to provide for the claims of learning and science by professorships to providing for them by headships. The miscellaneous duties of a Head would often be difficult to combine with professorial teaching or with scientific research.

13,736. And you, therefore, do not think that it would be a good plan to utilize, if I may use such a phrase, the headships as endowments for professorships, retaining, at the same time, their present official duties as headships?—I am hardly prepared to say no to that proposal, but I think it would often happen that a man would be an excellent Professor who would be an inefficient Head, or *vice-versâ.*

13,737. You, think, however, that it would be very important to found within the colleges, especially if they become by aggregation all of a certain size, University professorships, instead of taking their funds and founding University professorships external to them?—Certainly. I should attach great importance to founding professorships within the Colleges. It seems to me that several advantages would arise from that as compared with the plan of assessing the Colleges at a certain sum and founding professorships outside them. In the first place, you would considerably improve the position of the Professor; he would become a member of an ancient, and, in many cases, a powerful Society; he would also have certain advantages, such as belonging to a common room, having a share in the Councils of the College, and so on. It would also be a great advantage to the Colleges themselves. It seems to me that one of the principal points to aim at in a reform of the University is to improve the character of the present governing bodies of the Colleges. At present the governing body consists of the Head and Fellows. Several of the fellows are very young, and many of them are non-resident. I am not prepared to say that a non-resident element and a young element are not an advantage in the Councils of a College, but I think we ought to strengthen the older and more experienced element. It would, therefore, I conceive, be of great advantage to a College to include in its governing body a certain number of Professors of the University. For that and other reasons I should found within each College a certain number of professorships and assistant professorships. The governing body should consist mainly of Professors, Assistant Professors, and Tutors of a certain standing. To these elements might be added a certain number of the Fellows or representatives of the fellows; but when I

Rev. T. Fowler, M.A.

11 March 1873.

speak of Fellows, I mean fellows holding their fellowships on an entirely different tenure from the present. I conceive that all Fellows holding their fellowships upon the present tenure ought to be, and must be, members of the governing body of their College; but suppose that for the present fellowships were substituted terminable fellowships of a smaller amount and subject to no conditions of residence or celibacy, I should not see the same reasons for placing all the Fellows upon the governing body of a College.

13,738. With a grave governing body such as you have proposed, there would seem not to be so very much occasion for the services of a Head as there is at present?—I think the Head in such a Society would occupy a somewhat different position from what he does at present, and a position, I think, much more satisfactory to himself and much more satisfactory to the Society.

13,739. Are you aware of any circumstances in the special position of the natural and physical sciences which should render the principles which you have laid before us less applicable to them than to the other subjects of academical study?—No, I think not.

13,740. Reverting to the subject of the combined College lectures, are you not of opinion that when, in the great subject of modern history, you find 14 Colleges, and some of them large ones, combined into an union, for the purpose of joint instruction, it is time that that system of joint instruction was extended to the whole University?—Certainly.

13,741. Do you think that any useful purpose whatever is served by its being restricted to one half or two thirds of the University?—None whatever, but I think there might be room for catechetical lectures, to be given in the subject of modern history, in addition to the lectures I see upon this list, and such lectures I think might be given by smaller groups of Colleges.

13,742. Have you any impression that the effect of the combined system of College lectures is somewhat depressing upon those Colleges which are not included in the system of combination?—I should imagine that it is very depressing, and that such Colleges suffer great disadvantages from not entering into it. It is not uncommon, however, for a College which is not nominally included in the list to send its students to the combined lectures. One College has for many years sent several of its students to my own lectures, though its name does not appear in this list.

13,743. (*Dr. Sharpey.*) With reference to those Professors in Colleges whom you propose to institute, what would be their relation to the University Professors?—They would be the University Professors, but I should endow them out of a College, and make them members of the governing body of that College.

13,744. But in other respects, they would be Professors of the University?—Yes, I may say that what I propose is already done in a few instances.

13,745. (*Professor Smith.*) Do you think that that proposal would be more favourably received by the Colleges than the principle of taxing them?—I think it would be far more favourably received; in fact, I think there would be very little opposition to it in Oxford. I have talked on this subject to men of every variety of opinion in the University, and I believe there would be a large consensus of opinion in favour of abolishing many of the present fellowships and endowing out of the proceeds professorships, providing at the same time for some connexion between the Professors so endowed and the College.

13,746. Do you think there is any danger whatever of the position of a Professor being compromised or injured by his being placed in too close a connexion with a College?—I think there is no such danger.

13,747. (*Dr. Sharpey.*) Would you propose that those Professors connected with Colleges should be appointed by the governing body of the College?—Certainly not, but I think the governing body of the College might be allowed some voice in the appointment.

13,748. (*Professor Smith.*) The governing body being constituted as you have described?—Yes. In fact, I have often heard it said in Oxford that Colleges would be very good electors to professorships, provided they were not allowed to name a member of their own Society.

13,749. (*Professor Huxley.*) I have not quite clearly gathered to what extent you would propose to make the Professors subordinate to the Principal Professor; that is to say, how far they should be guided in their teaching by the arrangements made either by the Principal Professor alone, or by him in common with them?—I think that difficulty appears greater when stated theoretically than it would be found to be in practice. I think when the Professor, the Assistant Professors, and the Tutors met at the beginning of each Term to arrange their list of lectures, they would experience little practical difficulty; but I think anything like definite authority given to the Principal Professor would be resented. He would be the Chairman of the Board, and, unless under very exceptional circumstances, would consequently exercise great moral influence upon its decisions.

13,750. (*Dr. Sharpey.*) Then would you propose that there should be a separate board for each subject?—I think so, for every great subject. For instance, the Professor of Physiology would preside over his board; the Professor of Ancient History would preside over his board, and so on.

13,751. (*Professor Huxley.*) So that there would be an arrangement made at the beginning of each Term, as between the Tutors, the Professors, and the Principal Professors?—Yes, and I think, as a rule, their respective provinces would be sufficiently marked out to prevent one from caring to intrude on the province of another; and if any Assistant Professor or Tutor wished to give a course of lectures trenching upon the province of the Professor, instead of putting it down in the official list, he would probably give separate notice of it, and to that I should see no objection.

13,752. (*Chairman.*) As it would be very useful to the Commission, I beg to invite you to furnish us with a summary of the proposals for improvements which you would be disposed to make in the University?—I will supply it.

The witness withdrew.

[Summary of propositions, subsequently supplied by the Witness.]

(1.) To increase, to a slight extent, the present number of professorships, by founding new professorships in those subjects which are not at present represented in the University.

(2.) To found assistant professorships in those subjects which are most widely studied. It should be the function of the Assistant Professors to give lectures in the ordinary subjects of instruction in the honours schools, leaving to the Professors (or, as they might be called, Principal Professors) the more important or difficult branches of each subject. Though both classes of Professors should be required to lecture, the duties imposed on the Principal Professors should be sufficiently light to leave considerable leisure for study and research.

(3.) To found a third class of professorships, not subject to the condition of residence, and terminable. The duty of this third class of Professors should be simply to give certain courses of lectures. Residence not being required, the University might hope to secure in this manner the services of the most eminent men throughout the country for short periods of years.

(4.) For tutorial purposes, *i. e.*, for the purposes of advice, private assistance, and catechetical instruction, it is desirable that the Colleges should be united, more or less intimately, into groups. The absolute fusion of some of the smaller Colleges and Halls would be advisable, both for purposes of economy, and in order to increase the efficiency of the teaching and supervision.

Rev. T. Fowler, M.A.

11 March 1873.

(5.) The professorships and assistant professorships (or, as I should prefer to call them, the principal professorships and professorships) should be founded in the Colleges rather than out of revenues taken from the Colleges. By this intimate connection with the Colleges, the Professors themselves would gain in dignity and position, and the present condition of the governing bodies of the Colleges would be greatly improved by the addition of an older and more experienced element.

(6.) There should be great variety in the mode of appointment to the professorships. The Principal Professor ought to have an important voice in the appointment of an Assistant Professor in the same subject, and a College ought to have some voice in the appointment of Professors or Assistant Professors endowed out of its revenues.

(7.) With a view to the organisation of lectures, there might, at the beginning of each Term, be a meeting of the Professors, Assistant Professors, and Tutors lecturing in each subject, and at this meeting there might be drawn up a joint lecture list. But no person should be prohibited from giving additional lectures not contained in this list.

Prof. M. Lawson, M.A.

Professor MARMADUKE LAWSON, M.A., examined.

13,753. (*Chairman.*) I believe that you are Professor of Botany in the University of Oxford, and Curator of the Botanic Garden?—I am.

13,754. Will you be good enough to inform the Commission as to the origin of the Botanic Garden?—It was originally founded by Henry Danvers, Earl of Danby, for the purposes of scientific instruction and research. He enclosed it with walls and made it into a perfect garden; and he also left an estate from which it derives its revenues. After that Dr. Sherard, another great benefactor of the garden, also left a further sum for the erection of buildings in the garden, and since that time it has received certain grants from the University, and also many liberal benefactions from Dr. Daubeny, my predecessor in the Chair. The garden has had some very celebrated Curators, such as Morrison, Sherard, Dillenius, and also Dr. Sibthorp.

13,755. What is its present financial condition?—Financially it is in a bad condition. The keeping up of the garden has cost hitherto considerably more than there are funds for its maintenance, or, rather, I ought to say it has done so up to the present time, for there has been a considerable increase of nearly 100*l.* a year, which would under ordinary circumstances be sufficient for all purposes; but owing to the great rise in the cost of labour and in the price of coal, particularly the latter, I am afraid that that sum will be eaten up, and we shall have nothing left for the repairs of the garden without further grants from the University.

13,756. What can you say as respects the present efficiency of the garden for the purposes for which it was founded?—That I must say at present is very bad. The gardens contain a large number of plants, but they are in very bad order, owing to the want of larger houses and more room. The gardens and houses are very small for the number of plants which we have got crowded into them. The houses also are in exceedingly bad repair, and in some cases they are absolutely falling to pieces.

13,757. Looking to the future, would you be good enough to tell the Commission what you would desire to be done for the purposes of teaching at the Botanic Gardens?—For the purposes of teaching it is necessary, certainly, that we should have a garden of moderate size. I believe that a large garden is not required, but it should be a larger one than we have already. I believe also that we ought to have a large number of herbaceous plants, which are easy to keep up at a small expense. We ought also to have a large area covered with glass, but these houses ought to be low. They should be of no great height, so that their cubical contents would not be great; consequently, they would not be expensive to keep up, while they would be cheap to build and cheap to keep in repair, and they would grow a great number of plants for us.

13,758. Have you any suggestions to make for the improvement of the garden as to its use for original investigation?—I think the addition of a few houses for growing particular things would be all that would be necessary. What I think we ought to have in such a garden as the Botanic Garden at an University, are houses in which could be grown a sufficient number of plants belonging to some of the less known orders or genera, so as to enable the Professor or other botanist in the University to describe and monograph them; and there are many groups of plants, for a proper description of which living specimens are absolutely necessary, *e.g. Commelynaceæ*, *Bromeliaceæ*, and *Orchidaceæ*. I do not think we ought to compete with Kew and other large establishments, seeking to have a very large number of species growing at the same time. We ought, rather, to be content with having one or two groups well represented, and then, after all the use that is possible has been made of the collection, we should get rid of it, and begin another.

13,759. As respects the Herbarium, the Museum, and the Library, are there any impediments to the use of them for the purposes of instruction at the University?—With respect to the Herbarium, the plants have been very much injured through the attacks of insects, particularly the beetle. It is now, however, in a good state. It is not yet entirely arranged, but it is rapidly being so, and if the cabinets, which are at present exceedingly bad and utterly unsuited for the purposes to which they are applied, were replaced by new ones, the Herbarium would be in very good order and condition. With respect to the Museum, an immense portion of that has been wholly destroyed by the ravages of insects. Many gallons of poison have been washed over the different specimens, and I hope that that evil, if not completely remedied, is at least comparatively so. The room it is held in is also very bad: it is very dark, and it is quite unsuitable, and unfitted for the purposes of teaching. It is very useful for containing a number of specimens for purposes of lecturing, but for allowing men to go into the room and learn for themselves it is wholly useless. With respect to the Library, it is a very good one indeed, but it cannot be made of much use at present, at least not nearly of the use of which it ought to be capable, because it is separated from the Museum and from the Herbarium by the whole length of the garden; consequently, if you want any books at all to compare plants with, you have to go right through the garden to get them. It ought to be placed under the same roof with the Herbarium and with the Museum, in order to make it really useful.

13,760. Have you any further suggestions to make with respect to the Herbarium, the Museum, or the Library?—I think I have said all that I need say with respect to the Herbarium. The collection wants putting into new cabinets, and the rooms in which it is now held ought to be put in proper order; beyond that nothing more is wanting than the arrangement of the specimens, which is now going on. With respect to the Museum, I think it ought to be entirely remodelled. I think a good botanical collection of specimens of plants would be a most useful thing for teaching at the University. It might be done also, I think, very cheaply, and it might be arranged in such a manner that it might be made great use of by the students there. With respect to the Library, all I have to suggest is, that it should certainly be carried over to the same building where the Herbarium and the Museum are.

13,761. What is the position which the study of botany now holds in the University?—At the present time it is almost, I might say, absolutely ignored. In the general course of biology it is ignored altogether,

Prof. M. Lawson, M.A.

11 March 1873.

but any man who chooses to take up botany may take it up afterwards as a special subject. No man going in for a degree in the biological part of the Natural Science School, need necessarily know that such a thing as a plant exists upon the face of the earth. He never has a single question put to him in systematic or physiological botany, or, indeed, in any botanical branch at all. That is really the position it holds at present.

13,762. What would you suggest as respects the position which botany ought to hold in the studies of Natural Science in the University?—I would suggest that a certain amount of botanical learning should be made compulsory upon every one seeking a degree in the biological school. To what extent I am not altogether prepared to speak positively, but I think certainly some parts of physiological botany, and also, I think, some parts of systematic botany, ought to be taught to every one seeking a degree in the school.

13,763. Upon what branches of botany would you be inclined to insist the most in the University instruction?—If the amount to be taught were very small, then I should say that the part to be taught was that part of botany which borders upon the animal kingdom. I think that the distinctions which exist in the lower classes of plants, together with their developement, ought to be more particularly taught to the students, rather than beginning, as is often done now-a-days, at the other end, and teaching them the differences which exist in the higher classes of plants.

13,764. What amount of instruction would you require?—To make it full, I think, besides the lower orders of plants being fully described, I mean not merely by lectures but also by demonstrations, to which each man not only might go but should be compelled to go, so that he should have a practical acquaintance, at any rate, with the developement of the lower orders of plants—that I think is positively necessary—I say, in addition to that, I should like also to see everyone knowing something of the higher classes of plants. The students ought to be taken, I believe, through a regular course of systematic botany.

13,765. What is the staff at present available for the purposes of instruction in the University in botany?—There is none but myself to teach; nor, indeed, do I possess a lecture room. I have the herbarium to lecture in, and I have made it into a lecture room, but it is wholly unsuited for the purpose. Also, it is extremely inconvenient that the herbarium should be the only place for lecturing; for if, after a lecture, I wish to make use of the plants in the collection, I have to take all the diagrams down to get at them.

13,766. Have you any demonstrator or other assistant?—No; none. When I say I have no assistant, I have a boy to paste plants upon paper, to dust, and to do the common work of that sort in the herbarium, but beyond that I have no assistance.

13,767. Beyond such menial services, have you no assistance as curator in the management of the herbarium?—None at all.

13,768. Nor in the instruction of your classes?—Nor in that either.

13,769. From what sources have you conceived that funds might be derived for the improvement of the buildings of the museum and library, and for the general mechanical arrangements of the gardens?—Those funds could only be derived from the University as grants.

13,770. (*Professor Smith.*) Has there been any University grant since you have been professor?—A sum of, I believe, 250*l.* was expended upon the gardens, but that, if I am rightly informed, was merely a substitution of certain funds which had been laid aside for the repair of some estates.

13,771. Was that since you have been professor?—Yes.

13,772. (*Chairman.*) What is the resort of students, at present, to the study of botany?—I always have a few, and most of them are good men, or nearly always. Hitherto, I believe, only one man has taken up botany for his degree as a special subject, and I am happy to say that he got his first. The others that I get are men who come to me either after they have taken their degree, finding that their biological course, as taught at present in the University, is not sufficient for them, on account of botany being wholly excluded, or they are men who are going to pass some examination in London, either at the London University or for some Civil Service appointment.

13,773. Have you any suggestions to make with respect to the requirements of the University, as to its studies, which you think would tend to the encouragement of the resort of students for botanical instruction?—None, I think, so long as it is not made compulsory upon those who are going in for biology, because young men coming up to the University always ask you first of all what will pay. If you can conscientiously tell them that botany would pay in their degree, I have no doubt that they would take it up as readily as they would take up any other branch. But you cannot concientiously tell them that it will pay; in fact, you are obliged, in common honesty, to say that you believe, unless they are already very well up in it, it would be detrimental to them in taking their degree.

13,774. I understand you to say that you consider some such requirement, as to make botany an indispensable element of examination for a degree, or for honours, in Natural Science, to be a condition without which further success is not to be expected?—Yes.

13,775. Botany is not at present, I suppose, made in any degree serviceable towards obtaining scholarships or any other form of emolument in the University?—There is not a single scholarship in the University granted to a man for botanical proficiency, nor, indeed, is there any exhibition. There is one single prize given at one of the Colleges of the value of 10*l.* a year, but for that prize no student is required to go in for an examination. All that he is bound to do is to satisfy the Head of his College that he has collected 50 plants in the course of the year, and correctly named them. I am generally asked to look over the plants, to see that they are right, and constantly I have found that numbers of them were wrong, and I have no doubt, as one of the Fellows of the College has told me, that the way in which it is often done is this:—A man goes into the country and he gets his country cousins to tell him the English names of 50 plants; he collects those plants, then refers to his book, tacks the Latin name to the English name which they have given him, writes them down, brings them up, and gets his prize. Certainly those who have obtained the prize during the time that I have been in Oxford as professor have known no more of botany than would be implied in going through such a process as I have described.

13,776. Nor, I apprehend, is there any examination in botanical study in relation to the medical degree taken at Oxford?—I believe there is; but I have nothing to do with that. I am occasionally (not always) asked by the examiners to furnish them with a few of the commoner plants in December, and I should think that the examination must be rather imperfect, because men coming up for examination in December can see very readily what number of plants happen to be out in the garden at that time, a number probably varying from four in a cold season to 15 in a mild season; and so, knowing upon what flowers they will be examined, they can, with very little labour, acquire the requisite amount of information respecting them.

13,777. The examination, therefore, if it exist, is rather formal than efficient?—I think so.

13,778. According to your account, botany seems to have a nominal position in the University, as one of its studies, rather than a real one?—I believe its position is purely nominal.

13,779. (*Professor Huxley.*) Did I rightly understand you to say that a man might pass through the whole of his biological course without having had his attention directed to the correspondencies between the

Prof. M. Lawson, M.A.

11 March 1873.

structure of plants and the structure of animals, as laid down, for example, in Schwann's famous memoir?—I do not know what is done in the actual teaching, but in the examination he need not know anything even of that.

13,780. (*Professor Smith.*) You mean as regards the examination papers?—Yes. In the last four examination papers you will not find a single question bearing either directly or indirectly upon botany or the structure of plants.

13,781. You spoke of the revenue of the Botanic Garden, what is the amount of that revenue?—The total amount that passes through my hands is about 530*l.* a year, but, in addition to that, there is also 100*l.* a year, which is paid into the hands of Delegates for the sake of keeping the houses in repair, and not the houses only but the whole of the gardens.

13,782. The 530*l.* a year are chiefly derived from the original estate, are they not?—Yes, from the Kirkdale estate.

13,783. And from the Sherard benefaction?—No; that I believe is entirely paid to the Professor of Botany, but there is a grant from the Crown, and there is also an University rentcharge.

13,784. What is the government of the botanical garden? You are the Curator of the garden and the collections, are you not?—Yes.

13,785. But there is a Committee, is there not, or a Council of some kind?—There was an old garden Committee, consisting of the Vice-Chancellor, the two Proctors, and seven of the senior Physicians resident in Oxford; but there were not often that number of physicians resident in Oxford, and the board virtually consisted of the Vice-Chancellor and the two Proctors.

13,786. Is that board still in existence, or has it been swept away?—That board, I believe, has been swept away, but no other has been appointed, as yet, in its place.

13,787. It is supposed that a board is to be constituted before long, is it not?—Shortly a board will be appointed.

13,788. There has been some question, has there not, as to whether it would not be advisable for the University to give up the present botanical garden?—Yes.

13,789. It is not freehold, I believe, is it?—No.

13,790. And to transfer the garden into the immediate neighbourhood of the museum?—Yes.

13,791. Would you give us your views with reference to that proposal?—I have said already that the gardens are very small.

13,792. What is the area of the gardens?—The total area is under five acres, but that includes a great deal of ground which is made no use of at all for growing plants; it contains also the professor's residence and the library, the museum and the herbarium. In their present position, there is no possibility of largely increasing the area; there is a small piece belonging to Christ-Church, which that corporation might be willing to rent to us. On the other hand, if we went to the Parks we should be able to make a garden of any size; there would be plenty of room. But if we went to the Parks, it would be a very costly business to make new gardens, because we should have entirely to make our own ground, on account of the shallowness of the soil. In many places the soil of the Parks is only 9 inches deep. In the only portion of the Parks which would be in a fit position for a garden, the soil averages about 11 inches deep, I suppose not more. Beneath that is coarse worthless gravel.

13,793. Is the soil of the present garden good?—It is very good indeed, and of great depth; it has all been made. I suppose we have practically any depth of soil. In that respect we should lose in going to the Parks.

13,794. Have you formed any estimates as to what the comparative cost of moving the garden into the Parks would be, or, on the other hand, of renovating the houses which at present exist, and extending them as they ought to be extended?—At the desire of the Vice-Chancellor I obtained the advice of an agent in Oxford, and he informed me that to move the gardens, making them of the same size and capacity as the present, would cost about 11,000*l.*; and to put the present gardens into good working order would cost, I think, about 3,000*l.*, or between 3,000*l.* and 4,000*l.* That estimate seems excessive, but on such a matter it is impossible for a layman to judge. That estimate was entirely exclusive, I believe, of the expense of moving fresh earth on to the spot.

13,795. Is the Herbarium an extensive and valuable one?—Yes, it is a very extensive and valuable one. It would rank certainly not further down than the third or fourth in England and Scotland.

13,796. Is there any special fund appropriated to the maintenance of the Herbarium?—58*l.* a year.

13,797. Is that included in the sum you mentioned before?—No, it is exclusive of that.

13,798. Are there any similar funds for the maintenance of the museum and library?—No. The additions to them are purchased out of that sum, as also the salary which is paid to the assistant, whom I have already mentioned, for keeping the places in order and doing little things,

13,799. (*Dr. Sharpey.*) What number of students at present attend the class; how many had you in the last session, for example?—In the summer term I get about from 8 to 12, never I think more than 12, and I think I have never had fewer than 6. In the winter term, when I teach physiological botany, more by means of demonstrations than lectures, I do not get so many, but generally they are men of a very much better stamp than those who come to the other class.

13,800. So that, in the one term you teach systematic botany, and in the other physiological botany?—Yes.

13,801. Do the class frequent the garden and make use of it for study?—Yes, in the summer term they do.

13,802. Is it open to any other students besides those who attend your class?—It is open to every one.

13,803. Do many others make use of it?—Yes. Occasionally men who are not members of the University come to my lectures for a special purpose; for instance, I had the schoolmaster of a Wesleyan school in Oxford who desired to teach botany in his school, which contains over 800 boys, at least I believe that is about the number. He came with the object of learning a sufficient amount of botany to be able to teach it to his boys, and of course I took him with great pleasure.

13,804. What are the contents of the museum?—It is filled chiefly with specimens of economic interest. There are also other specimens for teaching, such as different sorts of seed vessels, arranged according to their natural orders. It is not the best arrangement there could be for teaching.

13,805. Do you think it would be advisable or practicable to make botany an alternative subject in the School of Natural Science with some other subject which is cognate to it: as, for example, zoology, giving an option to candidates as to which they would take up?—It is placed on that footing at present.

13,806. What was the date of the commencement of the Herbarium. Does that date from old times?—It dates from the foundation of the gardens. Morrison, who was physician to Charles I., was the founder of it.

13,807. Does it contain Dillenius' specimens?—Yes. It contains all Dillenius' specimens, as well as the whole of Sherard's, and the whole of Sibthorp's, besides other old collections.

13,808. Is it consulted by botanists not connected with the University for scientific objects?—Yes; I might say almost entirely by those not connected with the University. The only collection that the members of the University care about is a modern British herbarium which I have made since I came to Oxford.

13,809. By foreign botanists, for example?—Yes.

Prof. M. Lawson, M.A.

11 March 1873.

13,810. Do they frequently come for that purpose?—Generally when a foreign botanist is in England, if he has the time, he makes a point of coming down to see it. There are often botanists who want to see particular collections which are kept there, and who come down with the special object of consulting those collections. They are not very numerous. Professor Asa Gray came down to see it. Dr. Rupretch, of St. Petersburg, also came to consult a portion of it, to complete his book upon the Flora of St. Petersburg.

13,811. (*Chairman.*) Is there anything which you would consider might be proposed for the advancement of the study of botany in the University?—The establishment of a single yearly scholarship of even small value would be of immense assistance. It would create a competition, and when you once get a competition, you are sure to get men who, although they may fail to get the scholarship, will continue to work at the subject.

13,812. And if you had one scholarship which could be competed for in each of three successive years, and held during the period of study in the University, probably it would have an important influence upon the resort of students to your class?—I believe it would have a most important influence. It would determine many a man to take up the subject of botany, which now he has no inducement at all to take up, rather an inducement to forego, even if he has known a little of it before.

13,813. (*Professor Smith.*) You spoke of the scholarships which are given away in the Colleges for natural science. In the biological part of the examination for those scholarships, is there any reference to botany?—Yes; in some of them a few questions are sometimes asked, but they are of very little amount compared with the other part of the examination. I must correct myself upon that point. A student may take up the subject of botany, and he may be examined in it for a scholarship, so that in that way he might get a scholarship for botanical knowledge.

13,814. Have you ever known a scholarship got for botanical knowledge?—No, never, not a single one. I believe that only one man has ever taken botany up as a subject for his examination.

13,815. (*Chairman.*) Is there anything you would like to add to your evidence upon which we may not have made inquiries?—I think I have said all that I desire to say to the Commission.

The witness withdrew.

Adjourned.

No. 6, Old Palace Yard, Westminster, Friday, 14th November 1873.

PRESENT:

HIS GRACE THE DUKE OF DEVONSHIRE, K.G., IN THE CHAIR.

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART.
WILLIAM SHARPEY, ESQ., M.D., F.R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., Sec. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.

Deputation from Council of the Society of Arts.

14 Nov. 1873.

The following gentlemen attended as a DEPUTATION from the COUNCIL OF THE SOCIETY OF ARTS:—

Major-General F. Eardley-Wilmot, R.A., F.R.S., *Chairman of Council.*
Mr. Edwin Chadwick, C.B.
Lieut-Col. A. Strange, F.R.S.
Mr. Seymour Teulon.
Colonel A. Angus Croll.
Mr. Hyde Clarke.
The Rev. Septimus Hansard, M.A.
Admiral Ommanney, C.B., F.R.S.
Mr. James Heywood, F.R.S.
Mr. P. Le Neve Foster, *Secretary.*

(*Chairman to Major-General Wilmot.*) We understand that you have come as a Deputation from the Society of Arts, and that you wish to make some Statement to the Commission on the subject of National Museums.

(*Major-General Wilmot.*) Yes.

(*Chairman.*) Will you proceed to lay your views before us.

(*Major-General Wilmot.*) I think that the opinions of the gentlemen whom I have the honour to present to the Commission will satisfy you that they are all deeply interested in this question. We appear as a Deputation from the Council of the Society of Arts, having been appointed to bring before the Commission (understanding that they are engaged upon work connected with this subject) the views of the Society, and to say that those views are backed up by a large number of men all over the country, who are interested in the question of National Education in connexion with Museums. I may say that our opinion is, that the Great General Museum of the country is now of comparatively little use to the public, except as containing objects of interest and amusement, and so forth; but what we rather propose now is, not so much to go into the whole question with the Commission, as to lay before them the Resolutions to which the Council, on behalf of the Society, has come; those Resolutions being explanatory of the views of the Council of the Society upon this subject; and, if your Grace will allow me, I will read those Resolutions through.

The first Resolution is, that certain persons "be invited" (and I may mention that a large number have accepted the invitation, and I will hand in a list of those who at the present moment have consented to act as Committeemen upon this work) "to serve on a Standing Committee for the purpose of bringing under Parliamentary responsibility the National Museums and Galleries, so as to extend their benefits to Local Museums, and to make them bear on public education. The following are the several objects in view for effecting this purpose:—2. All museums and galleries supported or subsidised by Parliament to be made conducive to the advancement of education and technical instruction to the fullest extent, and be made to extend their advantages to the promotion of original investigations and works in Science and Art. 3. To extend the benefits of National Museums and Galleries to Local Museums of Science and Art which may desire to be in connexion, and to assist them with loans of objects. 4. To induce Parliament to grant sufficient funds to enable such objects to be systematically collected, especially in view of making such loans. 5. For carrying out these objects most efficiently, to cause all National Museums and Galleries to be placed under the authority of a Minister of the Crown, being a Member of the Cabinet, with direct responsibility to Parliament; thereby rendering unnecessary, for the purposes of executive administration, all unpaid and irresponsible Trustees, except those who are Trustees under bequests or deeds, who might continue to have the full powers of their Trusts, but should not be charged with the expenditure of Parliamentary votes." I will take the opportunity of saying that there has been considerable difficulty in getting the matter taken up by the Government; and

Deputation from Council of the Society of Arts.

14 Nov. 1873

in proof of that I will, after reading the Resolutions hand in a correspondence which has taken place with Mr. Gladstone upon that subject. "6. To enter into correspondence with all existing Local Museums and the numerous Schools of Science and Art, including music, now formed throughout the United Kingdom, and to publish suggestions for the establishment of Local Museums. 7. Also to cause the Public Libraries and Museums Act (18 & 19 Vict. c. 70) to be enlarged, in order to give local authorities increased powers of acting." In the absence of the Chairman of Council for the time being, Dr. Lyon Playfair was to be requested to act as Chairman of the Committee. The correspondence with Mr. Gladstone to which I have referred is as follows:—

BETHNAL GREEN MUSEUM

CORRESPONDENCE.

The Secretary of the Society of Arts, to the Right Hon. W. E. Gladstone, M.P.

SIR, 3rd July, 1873.

A MEMORIAL relative to the beneficial action of the Bethnal Green Museum, has been prepared by the Society of Arts for presentation to you.

It has been signed by 150 Members of the Council and of the Society, of whom 22 are Peers, and 63 are Members of the House of Commons. In addition to the above, 37 Peers and 63 Members of the House of Commons, not Members of the Society, have expressed their concurrence in the object of the Memorial.

I am directed to request that you will have the kindness to receive a Deputation to present the Memorial, and to name a day for doing so, giving, if possible, at least a week's notice.

I have, &c.
(Signed) P. LE NEVE FOSTER,
The Right Hon. W. E. Gladstone, M.P. Secretary.

Memorial enclosed. See Appendix below.

Mr. Gurdon to the Secretary.

10, Downing Street, Whitehall,
SIR, July 5th, 1873.

MR. GLADSTONE desires me to acknowledge the receipt of your letter of the 3rd inst., requesting him to receive a Deputation to present a Memorial from the Society of Arts, on the subject of the Museum at Bethnal Green.

I am directed to express Mr Gladstone's sincere regret that the pressure of his duties, as First Lord of the Treasury, renders it absolutely necessary that he should confine his attention to those matters which fall directly within his province; and he, therefore, trusts that those on whose behalf you have written will kindly excuse him if he asks them to address themselves to the Privy Council Office.

I have, &c.
(Signed) W. B. GURDON.
P. Le Neve Foster, Esq.

The Secretary to Mr. Gurdon.

Society for the Encouragement of Arts,
Manufactures, and Commerce,
SIR, John Street, Adelphi, 18th July 1873

I HAVE brought before the Council your letter of the 5th July, in reply to mine of the 3rd July, asking Mr. Gladstone to receive a Deputation to present a Memorial from this Society on the subject of the Bethnal Green Museum. The Council observe that you express Mr. Gladstone's regret that the pressure of his duties as First Lord of the Treasury renders it absolutely necessary that he should confine his attention to those matters which fall directly under his province, and his trust that those on whose behalf the reception of a Deputation was sought will kindly excuse him if he asks them to address themselves to the Privy Council Office.

I am directed, in reply, to point out that the Memorial, having relation to a subject of vast importance to the education, general cultivation, and social welfare of the people, did appear to the Council to bring the subject strictly within the consideration of the Prime Minister, rather than of a Department of the Government. Moreover, it did appear to the Council that the deep interest which the subject excites as manifested by the unusual character of the signatures, being those of 60 Peers and 130 Members of the House of Commons attached to the Memorial, and justified the Council in asking for the special attention of Mr. Gladstone himself.

Under these circumstances, the Council submit their conviction that the subject involves considerations of principle and policy worthy the attention of the Prime Minister of this country, and too wide in its political and fiscal considerations to be dealt with effectually by any single Department of the Government.

They, therefore, respectively decline to adopt Mr. Gladstone's suggestion that they should address themselves to the Privy Council Office.

I have, &c.
(Signed) P. LE NEVE FOSTER,
W. B. Gurdon, Esq. Secretary.

Mr. Gurdon to the Secretary.

10, Downing Street, Whitehall,
SIR, July 22, 1873.

I AM directed by Mr. Gladstone to acknowledge the receipt of your letter of the 18th instant, and to request that you will be kind enough to acquaint the Council of the Society of Arts that the intention of the reply to your communication of July 3rd was to point out that, in regard to a subject of the nature of that which you brought before him (viz., the beneficial action of the Bethnal Green Museum), which falls properly within the province of a Department of the State appointed to deal with it, the First Lord of the Treasury could not take the initiative out of the hands of that Department.

This Mr. Gladstone would be doing were he to receive the proposed Deputation; and he would be acting contrary to the rules of administration which are necessary for the conduct of public business.

If, however, the Society of Arts think fit to favour him with a written communication, Mr. Gladstone will himself correspond with the proper Department concerning it.

I have, &c.
P. Le Neve Foster, Esq. (Signed) W. B. GURDON.

The Secretary to the Right Hon. W. E. Gladstone, M.P.

Society for the Encouragement of Arts,
Manufactures, and Commerce,
John Street, Adelphi, W.C.,
SIR, 6th October 1873.

THE Council of the Society of Arts have directed me to reply to Mr. Gurdon's letter of the 22d July, in which he states that, "if the Society of Arts think fit to place before you a written communication, you would yourself correspond with the proper Department concerning it."

The Deputation which desired to have the honour of waiting on you, and explaining in detail the objects of the Memorial, would have stated that, in their view, the experiment of the Bethnal Green Museum is suggestive of the following points:—

1. That a general popular desire exists for such museums, and that it would be good national policy for the Government to encourage the establishment of them.

2. That like primary elementary schools, it would be impossible that such museums could, without State aid and inspection, become part of a National System, aiding technical instruction and secondary education.

3. That this question, unfettered by any denominational difficulties, is quite ripe for solution; that the necessary expenditure for aiding Museums of Science and Art would be advantageous from every point of view, even remunerative as respects commerce; and, further, would be auxiliary in promoting morality and social good order.

4. That such museums are absolutely necessary to the industrial progress of the country, which is behind other countries already in the possession of them.

5. That the time has come when it is necessary that all Public Museums and Galleries of works of Science and Art receiving Parliamentary aid, should be brought under an intelligible System of Administration, controlled by a responsible Minister of State, so as to render them auxiliary to the development of Local Museums and Galleries.

The Council submit that these are subjects not only of general policy, but involve some new principles of administration, large financial considerations, the reform of old institutions, &c., which it is the province of the general Government, and not of any single Department, to deal with. The Council especially desired that the answer they might receive should come direct from yourself as Prime Minister. They could not hide from themselves the knowledge they possessed of the several departmental difficulties which attended the opening of the Bethnal Green Museum, and that they had been made cognisant, through Parliamentary returns and the revised estimates for 1871-2, of the opposition which the Treasury, as lately administered, had persistently offered to carry into effect the decisions made by her Majesty's Government in 1866, for conducting the Bethnal Green Museum.

The Council respectfully request you to have the kindness to bring this Memorial before Her Majesty's Govern-

Deputation from Council of the Society of Arts.

14 Nov. 1873.

ment. They hope it will meet with favourable consideration and lead to decisive action; and they will feel obliged by receiving an answer upon it at as early a period as convenient.

I have, &c.
(Signed) P. Le Neve Foster,
The Right Hon. W. E. Gladstone, M.P. Secretary

Mr. Gurdon to the Secretary.

10, Downing Street, Whitehall,
Sir, 7th October 1873.

Mr. Gladstone desires me to acknowledge the receipt of your letter of October 6th, the contents of which he will not fail to make known to his colleagues.

I am, &c.
(Signed) W. B. Gurdon.
P. Le Neve Foster, Esq.

Appendix.

Memorial.

To the Right Honourable W. E. Gladstone, M.P.

1. We, the undersigned Members of the Council and Members of the Society for the Encouragement of Arts, Manufactures, and Commerce, request the attention of Her Majesty's Government to the remarkable proof of the public desire for instruction and pure enjoyment afforded by the examination of works of Art and Science, which has been shown by the opening of the Bethnal Green Museum.

2. This museum, established in one of the poorest and busiest districts in London, where men, women, and children are most laboriously employed, has been frequented during three months by more than 700,000* visitors, a number which probably exceeds that of the visitors to all the other Metropolitan Museums and Galleries during the same period.

3. The undersigned submit that this museum could never have come into useful existence, and have been instrumental in conferring great benefits on the people, without the aid of Parliament; and they desire to press this fact upon the consideration of Her Majesty's Government, with the hope that they will submit to Parliament the policy so essentially national of voting increased means to facilitate the establishment of Museums, Libraries, and Galleries of Science and Art in large centres of population, wherever such localities are willing to bear their share in the cost.

(*Here follow the signatures to the Memorial.*)

The following is a list of the noblemen and gentlemen who have consented to serve on the Standing Committee:—

F. A. Abel, F.R.S.
Colonel Akroyd, M.P.
Edmund Backhouse, M.P.
Bishop of Bath and Wells.
Sir Antonio Brady
Andrew Cassels.
John Cheetham.
Hyde Clarke.
S. S. Dickinson, M.P.
Sir Charles Dilke, Bt., M.P.
G. Dixon, M.P.
Joseph Dodds, M.P.
Lord Ebury.
William Finnie, M.P.
Lord O. A. Fitzgerald, M.P.
J. Gerstenberg.
Lord Ronald Leveson Gower, M.P.
Lt.-Col. W. Gray, M.P.
C. J. T. Hambro, M.P.
J. Snowdon Henry, M.P.
J. Heywood, F.R.S.
John Hick, M.P.
Samuel Holland, M.P.
Lord Kinnaird.
John Laird, M.P.
Earl of Lichfield.
Earl of Longford.
Lord Lyttelton.
W. McArthur, M.P.
P. McLagan, M.P.
Samuel Morley, M.P.
Vice-Admiral E. Ommanney, C.B., F.R.S.
Admiral Rt. Hon. Lord Clarence Paget, K.C.B.
Rt. Hon. Sir J. S. Pakington, Bt., M.P.
Love Jones-Parry, M.P.
Bishop of St. David's.
W. H. Smith, M.P.
Douglas Straight, M.P.
Duke of Sutherland.
E. C. Tufnell.
Thos. Twining.
Lord Vernon.
W. G. Ward.
Marquis of Westminster.
John Whitwell, M.P.
Bishop of Carlisle.
Earl of Carnarvon.
Lord Clinton.
Earl of Darnley.
Lord de Tabley.
Viscount Hardinge.
Duke of Portland.
E. A. Bowring, M.P.
W. T. Charley, M.P.
A. D. W. R. Baillie Cochrane, M.P.
Lord Richard Grosvenor, M.P.
A. E. Guest, M.P.
T. A. Mitchell, M.P.
A. J. Mundella, M.P.
J. H. Palmer, Q.C., M.P.
C. S. Read, M.P.
C. Reed, M.P.
N. M. de Rothschild, M.P.
Edward Wells, M.P.
Lord Elcho, M.P.
Lord Houghton.
Rt. Hon. Sir S. H. Northcote, M.P.
Sir William Thomson, F.R.S.
Henry Cole, C.B.
Warren de La Rue, F.R.S.
Gabriel Goldney, M.P.
U. J. Kay-Shuttleworth, M.P
Dr. Mouat.
Professor Roscoe, F.R.S.
Dr. Lyon Playfair, M.P., F.R.S.
Lt.-Col. A. Strange, F.R.S.
E. Thomas, F.R.S.
Colonel Angus A. Croll.
Also 54* Chairmen of Art and Science Schools.

E. Eardley-Wilmot,
14 Nov. 1873. Major General, *Chairman.*

*The following is a list of *some* of the Chairmen of Art and Science Schools above referred to:

James Barclay, M.P.	Aberdeen.
J. M. P. Montague, J.P.	Bridport.
P. W. S. Miles, M.P.	Bristol.
Canon Girdlestone	Bristol.
Dr. W. Rayner Cosens	Dudley.
C. J. Follett	Exeter.
J. Brinton	Kidderminster.
H. Gregson	Manchester.
Thos. Dawson	Leeds.
Rev. G. Butler	Liverpool.
Rev. Septimus Hansard	Bethnal Green.
E. J. Tabrum	Islington.
Peter Graham	West London Art School.
David Murray (Provost)	Paisley.
E. Pierce Grant	Portsmouth.
H. P. Hamilton (Dean)	Salisbury.
Revd. R. Cholmondeley	Shrewsbury.
Lord Lyttelton	Stourbridge.
Edward Vivian	Torquay.
Dr. George Ridding (Head Master of Winchester College).	Winchester.
R. J. Cowan	Worcester.
Canon R. H. Baynes	Coventry.
R. Allen	Preston.

I should say that the Standing Committee has not yet had an opportunity of meeting, as it is only to-day that the latest additions to the number of names have been received, and, therefore, no action has been taken upon this matter; but understanding that the Commission was very near the conclusion of its labours, we thought it our bounden duty to make known to you our interest in this work, and our great anxiety that it should be thoroughly and efficiently carried forward; and, therefore, we have taken the opportunity of coming before the Commission to-day. I do not propose to state on the part of the Council any definite arrangements which we think require to be made; I

---

* The numbers up to the end of September were upwards of one million and a half of people; to 31st December 1872, only six months and a half, they amounted to 901,164, whilst the numbers of the general visitors to the British Museum for the whole year of 1872 were only 424,068.—*October* 1873.

Deputation from Council of the Society of Arts.

14 Nov. 1873

think that the Resolutions which have been put forward by our Council sufficiently indicate the direction which we think such arrangements should take; but I will, if you will allow me, ask some of my friends who are with me to say a few words on any special point, not so much on behalf of the Council, as in explanation of their own views upon the question, which it may be interesting to the Commission to hear, and perhaps you will allow Mr. Chadwick to state his views.

(*Mr. Chadwick.*) My Lord Duke, the Society of Arts has bestowed great attention on the subject of secondary education throughout the country, and they are of opinion that when primary education is improved, and the time of teaching is reduced,—as I believe it may be assumed it will eventually be by some two or three years,—the time gained by such reduction may be and ought, extensively, to be given, by all middle-class children, to secondary education, in which it will be requisite to introduce a large amount of Art and Science teaching. That statement, as to the extent of Art and Science instruction required for secondary schools, will be justified by the examination of existing schools by anybody who may examine the good middle-class schools which are now instituted, such as the City of London School and others. Mr. Cole has stated, I think, as a matter of congratulation, that some 20,000 pupils are now obtaining direct Art and Science instruction under existing conditions, promoted by our Society; but if secondary education be carried on to the extent which the demands throughout the country necessitate, instead of some twenty thousand pupils, there ought to be some million of pupils receiving such instruction. In order that they may receive that instruction, we must get teachers to instruct them, and such teachers are at the present moment very few in number. But there is a position taken on this question to which I wish to advert, and which is apparent to the public, viz., the notion of the transference of the Art and Science teaching of the South Kensington Museum, such as it is, to the British Museum. I may mention that my friend Professor Owen has for a long time, some 10 years or more, urged that the Curators of the Collections at the British Museum should be, not merely Curators, Collectors, Catalogue makers, or ticketers, chiefly for the aged, and taught persons going to test and, perhaps, extend their acquired knowledge—altogether a few—but should be primary teachers—of teachers for the many. It has been objected, I see, that the Museum is not the place for popular lectures, but no such notion, I think, was entertained by Professor Owen, or would be entertained by others acquainted with what is required, of delivering merely popular lectures, lectures for amusement. What is intended is elementary lectures, lectures by the Curators to teachers on each special Art and Science Collection of which each Curator has the charge. The idea of taking the South Kensington Museum, with such means of Art and Science teaching as it has, and placing it under a non-scientific person or others, mere keepers of libraries, or, for the most part, mere caterers for literature, who have no conception of any use of them for elementary teaching, does appear to most of us to show a most deplorable deficiency of administrative conception, and to display a want of Art and Science and Economical Knowledge in high places. What is wanted is an authority, competent by scientific and economic knowledge, to combine existing means of scientific instruction, and also to judge of the advantages derivable by expenditure, or the means requisite to obtain extension of scientific knowledge for teaching and practice. As, for example: the means for Meteorological Observations, obtainable from private subscriptions, being miserably inadequate, application was made for a grant in aid, and refused. A competent scientific authority would, it is considered, have judged that such aid for the attainment of precise results in Meteorology, and thence of storm warnings, was necessary as a means of large economies of life and property, of some two millions in property, and one million annually in life, chiefly on our own coasts. The scientific knowledge so obtained would go to the science teaching of navigation in the secondary schools. When I was in office at the General Board of Health, money was wanted for trial works and gaugings, for the better determination of the sizes of drains and sewers. To judge of that application would have required some elementary scientific knowledge, or in its absence, the exposition of a system to which the Minister could give no time. So we expended 300*l.* without authority, on a chance of disallowance after expenditure, as preferable to the risk of a disallowance from ignorance before the expenditure. That expenditure, to a great extent, enabled us to direct the drainage of three houses and three towns, and at the expense, theretofore incurred, for one. More money was wanted for the completion of tables that would serve for structural Art and Science instruction in schools. I might multiply such examples of the wastefulness of high-seated ignorance. In my view, the Art and Science instruction which must be provided for in secondary education, and must enter so largely into any complete National System of Education, would render it expedient that the Science Minister should be the Education Minister. The need of a specially qualified Education Minister is becoming extensively felt. Mr. Bentham, in his Analysis of the Legislative and Administrative Functions of a Government in his Constitutional Code, has provided for a specially qualified Education Minister, with subordinates, having control over all public educational appliances and means of supplementing and improving them. That is, an Education Minister who really understands education, and has a mastery of it, and can be answerable for paying results—a functionary to stay great waste, who has been needed for a long time.

(*Lieutenant-Colonel Strange.*) I have already, as a witness before this Commission, so severely taxed their patience, and I have also so completely exhausted the recommendations which I have felt it my duty to make to the Commission, that it is with some diffidence that I again venture to address you; but being called upon by the Chairman of the Council of the Society of which I am a Member, I feel it my duty to say a few words in support of the recommendations which have been laid before you. I will confine myself to a single point, which has already been adverted to by our Chairman. I refer to the fifth Resolution of the Council, which states, "For carrying out these objects "most efficiently, to cause all National Museums and "Galleries to be placed under the authority of a "Minister of the Crown, being a Member of the "Cabinet, with direct responsibility to Parliament." The Chairman of the Council noticed, as he read that Resolution, that a correspondence had taken place with the Prime Minister of the Crown, which correspondence has been laid before you, and which bore upon the substance of that Resolution; and I shall confine myself to pointing out (which I am aware it is hardly necessary to do, but as a matter of form it may be convenient that I should point out) that this is one of the numerous illustrations which are occurring every day of the want of some central official authority, to whom scientific questions may be referred. It is far from my intention to animadvert upon the correspondence with Mr. Gladstone, and still less in the most indirect manner to attempt to blame him for the part which he has taken; but you will notice that in his first letter, in his reply to the Secretary of the Society, he expressly states his inability, on account of the pressure of his duties, to attend to such matters, and I think everybody will admit that Mr. Gladstone had ample grounds for pleading that as an excuse, for not only has he the enormous labour and duties of the Prime Minister to attend to, but he has now taken upon himself the additional duties of the Chancellor of the Exchequer. He then goes on to recommend the Council to take the matter before the Privy Council Office. I was one of those members of the Council of this Society who, on this coming to us, strenuously objected to relegating a question of this sort to such a Department as the Privy Council, a Department for which every-

Deputation from Council of the Society of Arts.

14 Nov. 1873.

body has the highest respect, but a Department which nobody supposes to be competent to deal with such matters. In saying that, I wish to confine myself to drawing the attention of the Commission to the fact that this correspondence strongly illustrates the existence of what, in my belief, is the greatest want with regard to the Science of England in the present day, that is to say, the want of a Minister, a Member of the Cabinet, who should have charge of all the action taken by the Nation in matters of Science. I think that if the Committee of the Society of Arts is called upon with reference to their Resolution, either by this Commission or by the Government, to state to which Minister they would wish to refer the museums question, they would at once have to say that they do not know, for there does not exist any Minister at present that we can suppose to be at all competent (I do not mean, of course, from personal incapacity, but from official constitution) to deal with such a subject. And, therefore, I wish pointedly to say that this is one of the numerous cases which have lately arisen, illustrative of the want of a Minister of Science. I refer to the question of the Arctic Expedition, to the question of Solar Eclipses, and to Meteorological questions, and to numerous cases which have lately arisen in which it is made evident that there are numbers of questions cropping up every day of the highest importance to the material welfare of the country which there is nobody to attend to.

(*Mr. Heywood.*) With respect to the British Museum, I may say that Sir Stafford Northcote, one of the Leading Trustees, and who responds for it in the House of Commons, in the same way that Sir Robert Inglis did formerly, has consented to join the Standing Committee of the Society of Arts, the object of which Committee is to place the National Museums under a responsible Minister of the Crown, having a seat in Parliament. The consequence is, that Sir Stafford Northcote may be considered not to be unfavourable himself to such a change; showing that in the body of the Trustees of the British Museum persons may be found who are willing to accept this alteration. Our point in coming before you, my Lord Duke, and the other Commissioners, is to say that we believe that it would be to the national advantage that there should be such a change. We understand that it is mooted that the South Kensington Museum should be placed under the Trustees of the British Museum. I reside near the South Kensington Museum, and know a good deal about it, and I should say that it would be a most unfortunate occurrence for that Institution if it should be put under the Trustees of the British Museum as at present constituted. In fact, it would stop all progress in that Institution, and it would lead, in my own neighbourhood, to public meetings on the subject, and great dissatisfaction. We consider it a matter of great pride to Kensington, that we have a splendid Seat of Science and Art in full vigour and prosperity there, and anything that would check it would create great popular feeling. I do not mean that we should be afraid of popular excitement if the change proposed were right, but I do not believe that it is right. I believe that the line that is taken by the Society of suggesting that such Museums should be placed under some Minister of the Crown is the best. The Chairman of our Council has already mentioned that our object is that Your Commissioners would take some notice of the subject in your forthcoming Report which we understand is under consideration at this moment.

(*Major-General Wilmot.*) I will just summarise quite shortly the three points which the Council really have in view. First, State Aid to Museums. Secondly, Museums to be made conducive to Education. And, thirdly, the Administration to be conducted by a responsible Minister. I think that in these three points I have embraced everything that we wish.

(*Chairman.*) In speaking of Museums and Galleries supported or subsidised by Parliament, what Museums and Galleries have you in view in addition to the National Museum?

(*Mr. Chadwick.*) In Manchester and in some other large towns and cities there are now museums.

(*Chairman.*) Are they subsidised by Parliament?

(*Mr. Chadwick.*) Bethnal Green, I believe, is, and I think there are one or two more that have a grant. Bethnal Green may be considered as part of South Kensington. I believe South Kensington has aided them very materially in giving them specimens, and so on, and helping them in various ways, indirectly, more or less. I believe all of them, to the extent of that aid which has been as active as the very limited means would allow, may be considered as somewhat subsidised.

(*Chairman.*) Is the Bethnal Green Exhibition to be considered as generally an Art Exhibition; is it connected with Science in any way?

(*Mr. Chadwick.*) Yes, it is. I understand that they either have, or are to have, Geological, Mineralogical, and other collections.

(*Rev. Septimus Hansard.*) It is to be regarded as a branch of South Kensington.

(*Chairman.*) Is the Bethnal Green Exhibition intended to be permanent?

(*Rev. Septimus Hansard.*) It is actually a branch of the South Kensington Museum, and just as the Jermyn Street Institution is solely for Geology, the original object was that the Bethnal Green Exhibition should be for Food and Animal Collections, and Art was an addition that came in afterwards.

(*Chairman.*) Has it not hitherto been principally confined to pictures?

(*Rev. Septimus Hansard.*) No, it is an Animal and Food Collection from South Kensington. It happens to be an Art Exhibition only because of the generous loan of Sir Richard Wallace, and I may say there is an Armour Collection there also.

(*Mr. Le Neve Foster.*) Our main point is, State Aid in the formation and the carrying out of those Museums, not only here, but in the country generally, and when we have Museums of that kind aided by the State, then that they should be placed under the Administration of a Responsible Minister.

(*Mr. Chadwick.*) And they should each be used locally for teaching teachers by elementary instruction upon those collections, with a view to secondary education.

(*Rev. Septimus Hansard.*) That is a most important item. In the original plan of the Bethnal Green Museum, it was especially made a point that there should be a Department for the Teaching of Science and Art, and giving instruction especially to the Teachers of Science and Art Schools. A letter which I wrote upon the subject, was accepted by the Privy Council, but nothing has come of it to this day. In spite of Deputations having waited upon the Lord President of the Council, and asked him to carry out his written promise, nothing has been done. It simply rests as it was.

(*Mr. Chadwick.*) Art collections and pictures have been used from time to time as a means for getting up popular support, and getting some money in aid of the very small amount of money that is really granted for Science. It is gallons of sack to a ha'porth of scientific bread in fact.

(*Chairman.*) Are we to understand that you distinctly recommend that courses of lectures should be delivered at the Bethnal Green Museum?

(*Mr. Chadwick.*) Not at the Bethnal Green Museum, but at South Kensington, or at the British Museum, in whatever collections are kept, and most distinctly that they should be lectures to teachers systematically on Natural History and Ichthyology, and all the various branches of Art and Science that are represented there; and then at South Kensington or in other places lectures would be given on Mineralogy as it is systematised at Jermyn Street.

(*Chairman.*) Is it part of your recommendation that the British Museum should lend specimens to the Local Museums?

Deputation from Council of the Society of Arts.

14 Nov. 1873.

(*Mr. Chadwick.*) That the public Art and Science authority, whatever it be, should be charged with the most efficient application of the public Art and Science means for Art and Science Teaching, whether by loans from one collection or another, or by gifts of duplicate specimens, according to circumstances. I am not particularly conversant with the administration of the South Kensington Museum, but I understand that it has facilitated the distribution of casts and specimens for local teaching, and also by aid from the officers of the establishment. Now, lately, lectures on the art of Cookery, which is a subordinate branch of Chemistry, which have been very successful, and will be given for extended local teaching in that vitally important art. At all events it ought to be a part of a system which some superior authority, with a competent knowledge of science, should have, as we conceive, the means and be charged with the duty of combining and systematizing scattered means efficiently and economically.

(*Sir J. P. Kay-Shuttleworth to Major-General Wilmot.*) May I ask you, with respect to paragraph 4 of these Recommendations, which is to this effect, "To induce Parliament to grant sufficient funds to "enable such objects to be systematically collected, "especially in view of making such loans of objects." Has the Council of the Society of Arts considered the question, whether they would recommend that any Department which might be entrusted with the collection and the distribution of specimens, should make a loan, or should make a grant of a Typical Museum, that is to say, whether the loan of a Typical Museum should continue to be the property of the Central Department and should be lent for purposes of instruction, and liable to be resumed at any time; or whether it should be a permanent grant to the locality to encourage further collection. Has that question been deliberately considered by the Council?

(*Major-General Wilmot.*) I think in making the Recommendation, the object in view at that time was simply loans, that is to say, that there should be certain branches of science carried on in certain districts by means of loans from any Central Museum under the direction of the Government. They would look more especially to places like Manchester to make their own collections for their own purposes.

(*Sir J. P. Kay-Shuttleworth.*) You are probably well aware that a systematic collection and arrangement of Typical Museums to be founded in the country, either by way of loan or by way of grant, would require the establishment of a completely new Department in connexion with the Museums, no such department existing at present.

(*Major-General Wilmot.*) I am aware that no such Department at present exists.

(*Sir J. P. Kay-Shuttleworth.*) That fact has been under the consideration of the Commission; and upon that, has your attention been given to the question, whether there should be a department which should systematically collect, arrange, and distribute either by way of loan or grant, such Typical Museums?

(*Major-General Wilmot.*) I do not think that the Council of the Society is prepared to say how that should be done, or whether a separate Department would be necessary to do it; but as to the necessity of doing it, that they feel very strongly.

(*Sir J. P. Kay-Shuttleworth.*) But they have not considered the mode?

(*Major-General Wilmot.*) No.

(*Lieutenant-Colonel Strange.*) It follows logically and necessarily from their recommendation.

(*Sir J. P. Kay-Shuttleworth.*) I merely want to know whether the Council have entered into it?

(*Lieutenant-Colonel Strange.*) No, the Council have not taken into consideration the mode of doing it.

(*Mr. Chadwick.*) The fact is, that in a matter of mere economy, it has been obligatory to talk of loans for the purpose of making the most of what we got. We have now no means of getting original collections; but as administration advances we presume that local original collections may be made in new centres or new points, or duplicate collections provided where it is necessary to have regular teaching.

(*Sir J. P. Kay-Shuttleworth.*) My question was rather as to the action of the Central Department, whether the question had presented itself in the light which I present it to you, General Wilmot?

(*Major-General Wilmot.*) No, it has not.

(*Professor Huxley.*) I understand the Deputation to be very anxious that instruction in various branches of Science should be given to the School-Masters, who are employed in Primary Schools in order that scientific instruction may be carried on by them throughout the country. I should like to ask the Chairman of the Deputation whether, in expressing that strong wish, the Council of the Society of Arts has any particular feeling as to where that instruction should be given,—whether it should be given at the British Museum itself, or at some other place that may be more convenient?

(*Major-General Wilmot.*) I think that the view of the Council is distinctly that instruction should be given wherever there is an opportunity of doing it, and not only at the British Museum, if possible, and at the South Kensington Museum, and other Museums, but also at Museums established in different parts of the kingdom; that is to say, that men who want instruction at Manchester, for instance, should not be forced to come to London for it, but that they should have the means of obtaining it in the form of loans from the Great Central Museum under the charge of the Government.

(*Professor Huxley.*) I presume the Council are aware that at the present moment instruction is given to Teachers in Elementary Science for the express purpose to which the Council refers, but it is given in the Science Schools at South Kensington, where there is instruction given in Chemistry, Physics, and Natural History. The point that I wish to put is, whether the Council think it more convenient that the instruction should be given at Museums rather than in the Science Schools, and if they hold that opinion, for what reason they hold it?

(*Major-General Wilmot.*) I think the opinion is that it should be given at both.

(*Professor Huxley.*) Have they carefully considered what the duties of a Curator of a Collection are, and how much of his time is occupied, and whether it is convenient to burden that person with instruction in addition.

(*Major-General Wilmot.*) I do not think that they at all desire to put it upon the Curator, as at present existing, but they wish to have Teachers of some sort or other for that particular purpose. Whether the duties can be combined with that of Curator remains to be seen. The object is to have the instruction given at as many depôts as possible, if I may use the expression.

(*Professor Huxley.*) Have they at all considered whether it would be any particular advantage to have the instruction given in the British Museum, seeing that for the purpose of elementary instruction very small and comparatively insignificant collections are quite sufficient.

(*Major-General Wilmot.*) The position of the British Museum makes it a very desirable place for instruction, though a large portion of its contents might not be needful.

(*Professor Huxley.*) The point is of importance in this way, that the keeping up of a collection, the naming of the specimens in it, and doing all the work of the museum properly, is in itself a very large branch of business, sufficient to occupy a very large staff of officers, and for the purposes of elementary instruction you really do not want a twentieth part, or I may say a fifteenth part of the specimens contained in the British Museum, so that there is no reason in the nature of the case why you should have Elementary Instruction given in the British Museum if it can be more conveniently given elsewhere. I should be glad to know whether the Council have considered that?

Deputation from Council of the Society of Arts.

14 Nov. 1873.

(*Major-General Wilmot.*) The British Museum contains a vast deal more than can be used in anything like ordinary instruction, but of course it exhibits a very great deal of what to comparatively instructed persons is of value, but is of no value to those who merely walk through it as a sight. So far as regards the convenience of being close to a large representative establishment like that, the Council conceive it would be an advantage to have the means of giving instruction on the spot.

(*Professor Huxley.*) I am not for a moment suggesting that the British Museum collection should not be used for the purpose of public instruction; it may be used for public instruction in a great many ways, but that is a separate point altogether from endeavouring to set up in the British Museum the instruction to Schoolmasters which has been specially referred to. What I want to know is whether the Council of the Society of Arts have really, in making this recommendation, bethought them that there is no real connexion between the instruction to be given to School masters and the great collections at the British Museum?

(*Mr. Chadwick.*) There are professors there who have thought about it, and who do think that there is a very important connexion. I should state, that I believe that two or three of the Curators of the Collection——

(*Professor Huxley.*) Pardon me for interrupting you; all this has been before us in evidence, and we know the opinions of those gentlemen; but what I want to get at now is whether the opinion of the Deputation before us is the opinion of the Council of the Society of Arts?

(*Mr. Chadwick.*) It is our opinion that teachers ought to be taught by the most eminent Professors or Curators, and that a Professor, as a Lecturer or Teacher, might sometimes find it convenient to teach at the Museum, and sometimes at South Kensington, according to circumstances, and the conveniences as to the collections.

(*Professor Huxley.*) Am I to understand from the Chairman of the Society of Arts that this question has been thoroughly discussed by the Council of the Society, and that that is their deliberate judgment?

(*Major-General Wilmot.*) It is our deliberate judgment that the British Museum might from its situation, very advantageously be a place for giving that instruction.

(*Lieutenant-Colonel Strange.*) Perhaps I may help the Commission to get over this difficulty by reminding you of what was stated at the outset by the Chairman of the Council, that the Council of the Society of Arts have not even sketched any scheme, but that they have merely laid down a few broad principles or outlines of a scheme, and they have appointed a Committee to fill in the details. The first Resolution refers to the matter that Professor Huxley has been investigating, and it simply says, "That the "under-mentioned persons be invited to serve on a "Standing Committee for the purpose of bringing "under Parliamentary Responsibility the National "Museums and Galleries, so as to extend their bene-"fits to Local Museums, and to make them bear on "Public Education." The Council in saying that simply meant this, that at present there are certain museums which do not in our opinion bear upon public education, that particularly the British Museum is not brought to bear, and that it should be brought to bear. We appointed a Committee to ascertain in what respect they fail to do this, and how it can best be done, but I think that the Council is certainly not in a position to recommend, and I am sure that this Deputation is not authorised to state the specific manner in which any of those objects should be carried out.

(*Major-General Wilmot.*) I mentioned that these gentlemen would speak their own views merely.

(*Sir J. P. Kay-Shuttleworth.*) We understand that the gentlemen who have spoken have given their individual opinions, but not the collective opinion of the Council?

(*Lieutenant-Colonel Strange.*) Precisely so.

(*Sir J. P. Kay-Shuttleworth.*) Upon this very important question of the best mode of introducing scientific instruction, with the aid of museums, into the elementary, or the secondary education of the country, the Council are not yet prepared to lay before us any proposition?

(*Lieutenant-Colonel Strange.*) Precisely. It may be thought that we were premature in coming before you, but we hope that it will not be considered so. We give the Commission the earliest intimation that this action is going on in the Society of Arts.

(*Chairman.*) Your second Resolution is to this effect:—"All Museums and Galleries supported or "subsidised by Parliament to be made conducive to "the advancement of education and technical instruc-"tion to the fullest extent, and be made to extend "their advantages to the promotion of original in-"vestigations and works in Science and Art." Is it intended to imply that the British Museum is not available for such purposes at present? Are not the Collections at the British Museum available to any persons who wish to make use of them for the purpose of original investigation?

(*Lieutenant-Colonel Strange.*) Not sufficiently so. I do not state that as my opinion, but as the result of my inquiries amongst those interested in Natural History pursuits, that the British Museum does not assist Science to anything like the extent to which such an enormous and valuable collection might do.

(*Chairman.*) Is there anything that you wish to add to what you have already stated?

(*Major-General Wilmot.*) I am not aware of anything further.

The Deputation withdrew.

Adjourned.

No. 6, Old Palace Yard, Westminster, Friday, 21st November 1873.

PRESENT:

SIR JAMES PHILLIPS KAY-SHUTTLEWORTH, BART., IN THE CHAIR.

WILLIAM SHARPEY, ESQ., M.D., F.R.S.
THOMAS HENRY HUXLEY, ESQ., LL.D., Sec. R.S.
GEORGE GABRIEL STOKES, ESQ., M.A., LL.D., Sec. R.S.

TRENHAM REEKS, ESQ., further examined.

T. Reeks, Esq.

21 Nov. 1873.

13,816. (*Chairman.*) Will you have the goodness to state to the Commission what office you hold?—I am Curator and Librarian of the Museum of Practical Geology in Jermyn Street.

13,817. You attend, do you not, for the purpose of presenting to the Commission a statement which you have prepared with regard to the Museum of Practical Geology?—Yes.

13,818. Will you kindly state to the Commission the information which you have prepared?—I have

T. Reeks, Esq.

21 Nov. 1873.

prepared it with a view to giving an account, as briefly as possible, of the history, the objects, and the expense of the Museum.

Its History.—The origin of this Museum may be traced to a suggestion made by the late Sir Henry T. De la Beche to the Chancellor of the Exchequer in July 1835. In the previous year, the Geological Survey of the United Kingdom had been commenced, in connexion with the Ordnance Survey; and it occurred to Sir Henry, who conducted the geological work, that an excellent opportunity was thus afforded of collecting specimens illustrative of the application of geology to the useful arts. In submitting an official representation to this effect, he took occasion to point out the advantage of exhibiting such collections for purposes of National Instruction. These suggestions, having duly received the approval of the Government, led to the foundation of the Museum of Economic Geology. In February 1837, Lord Duncannon, then Chief Commissioner of Woods and Forests, requested Sir Henry to proceed with the formation of such a Museum; and for this purpose apartments were appropriated at No. 6, Craig's Court, Charing Cross. The administration of the Institution was controlled by the Board of Works; Sir Henry acted as Director, and Mr. R. Phillips was soon afterwards appointed Curator of the Collections. As the Museum gradually extended its spheres of usefulness, it gave rise to other Institutions having collateral objects; and in this way the Mining Record Office and the Government (now Royal) School of Mines came to be developed in immediate connexion with the Museum. The rapid growth of the Collections led to the erection of a special building for their accommodation, and for that of the affiliated Institutions. This building is the Museum between Jermyn Street and Piccadilly, which was erected from the designs of the late Mr. J. Pennethorne, under instructions from the Department of Woods and Forests. The Museum of Practical Geology was opened to the public by H.R.H. the late Prince Consort on May 14th, 1851. On the death of Mr. Phillips, which occurred at this date, Mr. Trenham Reeks was appointed to the Curatorship. In 1854, the Committees of Inquiry into Public Offices issued a Report, in which they recommended that the Lecturers in the School of Mines should have special charge of such Departments of the Museum as related to their respective subjects, whilst the general superintendence of the collections should be placed in the hands of the Curator. The present organization of the Museum is based upon these recommendations. Sir Henry De la Beche died in 1855, and was succeeded in office by Sir Roderick I. Murchison. After Sir Roderick's death, in 1871, the Direction of the Museum passed to Professor Ramsay.

Its Objects.—The primary object of this Museum is to exhibit the industrial applications of geology and the kindred sciences, with special reference to the mineral resources of this country and its dependencies. With this view the following collections are comprised in the museum:—(*a.*) Specimens of British building stones, polished marbles, and other ornamental stones, used for constructive and decorative purposes. (*b.*) A collection of British, colonial, and foreign minerals, specially selected for their economic value or for their importance to the student of mineralogy, geology, and mining. (*c.*) A metallurgical series, comprising specimens illustrating the smelting of ores, and the industrial applications of metals and metallurgical products. (*d.*) Models of mines and mining machinery, with examples of mining tools; models of ore-dressing apparatus, furnaces, and metallurgical appliances; with geological and topographical models of special localities. (*e.*) A collection of specimens showing the technological applications of clays, and fully representing the history and present position of British Ceramic Art; with illustrations of manufactures in glass and enamels. (*f.*) The palæontological collections, embracing a large series of British fossils, stratigraphically arranged. (*g.*) A petrological collection, comprising specimens of the igneous, metamorphic, and stratified rocks of Great Britain. (*h.*) A library of upwards of 20,000 volumes, including works on all those branches of science which find illustration in the collections exhibited in the Museum.

The Museum is open gratuitously to the public on Mondays and Saturdays from 10 a.m. til 10 p.m., and on the other days of the week (Friday excepted, from 10 a.m. till 4 p.m., during the months of November, December, January, and February; and until 5 p.m. during the remainder of the year, with the exception of one month's vacation from the 10th of August to the 10th of September. The library is too small to be thrown open to the public, but permission to consult any work is always granted on proper application being made. The works in the library are referred to chiefly by the Officers of the Museum; by the Lecturers, Associates, and Students of the Royal School of Mines; and by the Officers of the Geological Survey of Great Britain.

Its Expense.—The amount annually taken for the maintenance of the Museum is four thousand and fifty four pounds (4,054*l.*). This sum is made up of the following items:—

	£
For salaries and wages - - -	1,584
,, Purchase of specimens and books -	500
,, Purchase of mining models -	200
,, Furniture - -	500
,, Heating and lighting - -	700
,, Incidental expenses - - -	170
,, Police - - - - - -	400
Total	£4,054

This amount is exclusive of the expense of the Mining Record Office and of the Royal School of Mines, and also of rents, rates, &c.

13,819. I observe that you state that on Mondays and Saturdays the Museum is open until 10 o'clock in the evening. Have you any means of ascertaining the expense which is incurred for the extension of the time during which the Museum is open after 4 o'clock on those days?—The expense is chiefly caused by the gas; and I estimate that it costs, for the five hours, say from 5 o'clock till 10, about 5*l.* at least a night.

13,820. Being at the rate of 10*l.* a week?—Yes.

13,821. And in the whole year about what would you say?—About 500*l.*

13,822. What number of persons attend usually on the evenings of Monday and Saturday?—I have taken the number in 1871, and I find, leaving out hundreds, that there were 25,000 in the morning and 25,000 in the evening; and in 1872, 27,000 and 21,000 in the morning and evening respectively; but those numbers I should say are very materially affected by the evening lectures, because all who apply for tickets and who attend the lectures pass through the registering stile, and are counted as visitors.

13,823. But during the evenings of Monday and Saturday, have you any separate means of ascertaining the numbers?—I estimate that there are 15 in an hour, or about 75 in an evening of five hours, and, extending that, it would be 600 in a month, or about 6,600 in the 11 months that the Museum is open during those two evenings.

13,824. So that the expense would be at the rate of 500*l.* a year for 6,600 persons?—Yes, about that; but that is for the gas only.

13,825. Is there any extra attendance involved?—That is very small, indeed, costing probably about 10*l.* in the year, but the lighting by gas necessitates the constant cleaning of the specimens and the roof; and this cleaning is a very large item, because the roof is so constructed that all the cases have to be boarded over, and scaffolding has to be erected, before it can be cleaned, and what was formerly required once, probably, in seven years, must be done now every fourth year at least.

13,826. Do you think that the expense of that cleaning is greatly increased by the evening attendance?—Very much so, indeed. The gas blackens the ceiling quickly, and it draws a great deal of dust and dirt into the building; it expands the air and carries dust into the cases, and so necessitates the cleaning of the specimens more frequently than would otherwise be required.

13,827. If the evening attendance on the Mondays and Saturdays were given up, how much saving do you think might be effected in the matter of cleaning alone?—It is not only the expense, but the trouble of maintaining the Collections and the building in order, and the liabilities to damage. If the Museum were open to the public only on the evenings on which lectures are delivered, I think a direct saving of expense might be effected, certainly amounting to 300*l.* or 400*l.* a year.

13,828. (*Professor Stokes.*) Besides the gas, or including it?—I mean for the gas alone.

T. Reeks, Esq.

21 Nov. 1873.

13,829. (*Dr. Sharpey.*) It would be on those lecture evenings, would it not, that the visitors would chiefly come?—Yes; there is a large attendance on the lecture evenings, and on other evenings they come at the rate of 15 an hour. They are generally people who stroll in because they see the building open, and lighted up. I do not think that they can derive much benefit from coming, because the chief collections are minerals and fossils, and you cannot examine and discriminate them minutely by gas light.

13,830. (*Chairman.*) Do the persons who attend after 4 o'clock on the evenings which are not lecture evenings appear to be attracted simply by curiosity, or do they come for the purposes of study?—I think they come simply from curiosity. For hours together you may not see a soul in the Museum, but when it is lighted up, then, perhaps, half a dozen or more will stroll in; certainly they are not students.

13,831. So that you estimate that 400*l.* a year is almost uselessly expended in the gratification of an idle curiosity?—Not only so, but the specimens are deteriorated, and the building itself also.

The witness withdrew.

Major John F. D. Donnelly, R.E., further examined.

Maj. J. F. D. Donnelly, R.E.

13832. (*Chairman.*) The Commission understand that you attend for the purpose of presenting to us some Statement with respect to the Museum at South Kensington?—I have prepared a short Statement with the aid of the officers in charge of the different branches of the Museum at South Kensington which bear upon Science.

13833. Will you be kind enough to lay the information before the Commission?—The Collections bearing on Science in the South Kensington Museum are (1.) The Educational Library; (2.) The Educational Museum; (3.) The Food Museum; (4.) The Animal Products Museum; (5.) Structure and Building Materials; (6.) Models of Machinery, Ships, and Military and Naval Appliances; (7.) Economic Entomology and Forestry; (8.) Fish Culture; and (9.) The Patent Museum. With regard to the first two, the Educational Library and the Educational Museum, the Library consists of books bearing on Education, and the Educational Museum is a collection of school furniture and fittings, philosophical instruments, apparatus for scientific and other instruction, specimens and diagrams of Natural History, including mineralogy and geology, and other educational appliances, such as drawing materials, &c. The origin of the Library and Collections is due to an Educational Exhibition formed by the Society of Arts, and held in St. Martin's Hall in the summer of 1854. When this Exhibition closed, many of the contents, English and Foreign, were placed by the Exhibitors at the disposal of the Society, and a strong desire was expressed that it should become a permanent Institution. The Collection thus formed was offered to and accepted by the Government. The division of the South Kensington Museum was first opened to the public in 1857, and occupied a portion of the iron building which has since been removed to Bethnal Green. The collection is now placed in the temporary buildings adjoining the western side of the permanent Art Museum Buildings at South Kensington. The collections have been principally formed by gifts from the chief manufacturers of educational appliances, and also from the publishers of school books, who were invited to contribute, and who responded with a liberality which is highly commendable, and which has been continued down to the present time. Numerous gifts have since been made to the collection by Foreign Governments, and especially at the close of the Exhibitions of 1862 and 1871. Latterly, in consequence of the great demand for educational works on scientific subjects, the vote for purchases has been very largely expended in collecting books of that nature, Foreign as well as English. Special collections of apparatus have also lately been formed, for teaching the various branches of Science. These have been formed on the advice and recommendation of the several Examiners in the different subjects, who have said what they thought was the kind of collection that a school should possess. There are two or three duplicate sets of each apparatus, which are sent round to the different Schools of the country, and they are lent to a school for a week, or a fortnight, or three weeks, as the case may be, so that the Committee and the Teachers of the Schools may see what really is the kind and amount of appliance that they ought to have for their class instruction. The first Catalogue of the Library and Collection was issued in 1857, and covered 160 pages. The ninth edition, now going through the press, will, it is believed, reach 650 pages. The total number of books and pamphlets in the library exceeds 30,000. A Reading Room, ill-adapted and much too small for the purpose, is attached to the Library. It is open during the same hours as the Museum, and is chiefly frequented by students, teachers, clergymen, school-managers, and others who wish to consult special books, or to become acquainted with the best educational works on the various subjects. The number of readers in 1872 was 15,366, an average of nearly 50 a day. On some days the attendance has reached 136, and were it not for the limited accommodation, it would largely exceed this number. The proposal has always been that as soon as we are allowed to go on with the building at South Kensington, the buildings for the Educational Division, both the Museum and the Library, should be the very first undertaken; but the question of continuing the building is at present in abeyance, and both the Collections and the Library are exceedingly badly housed at the present time.

13,834. (*Professor Stokes.*) I observe that you mention a Collection of Philosophical Instruments in connection with the collection of school furniture and fittings. I should suppose, from the context, that those instruments are rather of a nature to illustrate lectures of a somewhat elementary character than instruments of the first class, such as are employed by Scientific Men in their Researches for the Advancement of Science?—No, there are several instruments of a higher class than would be used for ordinary elementary instruction. I do not know that there is a very large collection of them that can be exhibited at the present time; but we have, for instance, a large model of the transit instrument, and other instruments, I think, belonging to the Greenwich Observatory. There are several instruments exhibited that one would not call apparatus for elementary school teaching, and it was not at all intended to restrict the collection to such appliances. In consequence of the want of space, we have not been purchasing a higher class of instruments of that kind, but they would certainly be accepted and exhibited, if possible, if the instrument makers chose to send them.

13,835. Then you are dependent for such instruments upon gifts from the instrument makers?—At present we are. It is, in fact, so impossible to exhibit what we have, that it would be of no use for us to make purchases at the present time, but I have no doubt that if we had more space, we should not only have numbers of instruments sent in by instrument makers to exhibit, as it is a place where many people go to look at instruments, but we should also supplement the collection by purchasing anything that was thought desirable.

13,836. (*Chairman.*) The result of your observations is, that the Collection of Philosophical Instruments is not and cannot become complete unless the buildings be very considerably enlarged, and made more convenient?—Precisely so.

13,837. (*Dr. Sharpey.*) In the case of some large

Maj. J. F. D. Donnelly, R.E.

21 Nov. 1873.

and expensive instruments, you content yourselves, do you not, with models?—Yes, that has been done.

13,838. Then I presume that the instruments that are sent round to the different schools would not comprehend delicate and expensive apparatus, but would be more of such a character as might be purchased for a school?—Yes, some of them are not of a very cheap or elementary character. These two lists which I beg leave to hand in (*delivering in the same*) would show that. The Commission will see by them what is proposed by one or two of the Professors, and those lists certainly contain some very expensive instruments. The object of the lists is that the Teachers or Committees should see really all that they require, not that they should necessarily buy it all at once. Those lists go to many towns which can very well afford to purchase this apparatus, because the Department gives a grant of 50 per cent. upon the cost of the apparatus.

13,839. (*Chairman.*) With reference to the extension of the buildings, have you at all considered where those buildings could be most conveniently erected for educational purposes?—The proposed plan for the extension of the buildings shows this:—It is on the west wing corresponding to the existing permanent east wing, which has already been built, and which contains the Art Collections. Along the passage connecting the two, it was proposed to place the Educational Library on one side, and the Art Library on the other side of the central entrance. Then beyond the Art Library would come the Art Museum, and beyond the Educational Library would come the Educational Collections and Museum.

13,840. Will you proceed to describe the Food Museum?—The formation of this collection was commenced in 1858. The idea oringinated with Mr. Thomas Twining, who induced the Society of Arts to co-operate with him in the establishment of an Economic Museum. His idea was a very extensive one—an Economic Museum in its fullest conception. The demands for space in the South Kensington Museum did not permit of the exhibition of all the objects contemplated, but it was considered desirable to exhibit the section illustrating the nature and sources of human food. The Collection has been formed with a view to show, first, the chemical composition of the various substances used as food; secondly, the sources from which all varieties of food are obtained; and thirdly, the various substances used for adulteration, and the best methods of detecting them. Inventories, catalogues, and guides of this Collection have been published, the last editions having been revised by Professors Huxley and Frankland. I produce the inventory of the Food Collection (*delivering in the same*). A complete collection of the chemical analyses of food is used for circulation to Country Schools and Museums; it is left there for a certain time, and then brought back again, and sent to any other place that may wish for it. A series of large descriptive labels has been prepared, and these are supplied to any country museums who may apply for them. Of course with these large descriptive labels which give the analyses and the proximate composition of the various substances, it is very easy for a Local Museum to make a complete collection at really a very small cost.

13,841. To what Museums have these labels been supplied?—I do not at the present time remember many of the Museums, but I may mention Edinburgh, Exeter, Keighley.

13,842. Will you describe the Animal Products Museum?—With regard to the Animal Products Museum, this collection owes its origin to the Commissioners for the Exhibition of 1851, and the theory with which it was started was this,—that in the Museums at Kew and Jermyn Street there were collections, illustrative of the Economical Applications of Mineral and Vegetable Substances, but that there was no such representation of the uses of the Animal Kingdom. The Royal Commissioners for the Exhibition of 1851, in co-operation with the Society of Arts, formed a Collection of Animal Products, which was exhibited in the Society's premises in 1855. A portion of this collection was moved to the South Kensington Museum, and formed the nucleus of the present collection, which was opened to the public in 1857. The collection consists of animal substances employed in textile manufactures and clothing; substances used for domestic and ornamental purposes; pigments and dyes yielded by animals; animal substances used in pharmacy and in perfumery; and the application of waste matters, together with illustrations of the processes of manufacture. This Collection again, for want of space, has been but little developed of late years. It is now entirely moved to the Bethnal Green Museum, along with the Food Collection. This short Guide to the Animal Products Collection will show the kind of thing (*delivering in the same*). As I have said, it is now entirely removed to Bethnal Green, excepting the Circulating Collection.

13,843. (*Dr. Sharpey.*) Are these Collections to remain permanently at Bethnal Green?—I can hardly say "permanently," because the theory is, that Bethnal Green shall be, not a speciality of itself, but a branch of the South Kensington Museum; and, from time to time, an alteration may be made, as to what portion of the collection shall go there, and what shall remain at South Kensington. The Collection of Animal Products is a very interesting collection. I do not know that there was any part of the Museum in which the people were more interested than in the Animal Products Collection, except, perhaps, the Food Collection, which was almost always more full of visitors than any other part of the Museum.

13,844. (*Chairman.*) Will you now go on to the Museum of Construction and Building Materials?—The Museum of Construction and Building Materials had its origin in a large number of models and specimens which were presented to Her Majesty's Commissioners for the Exhibition of 1851, at its close. On the establishment of the Museum at South Kensington in 1857, these contributions were presented by the Royal Commissioners to the Department of Science and Art. In 1858, the Collection was placed under the Superintendence of the late Captain F. Fowke, R.E. At this time, the whole of the models of construction, and of the materials used in building, were exhibited in the South Kensington Museum. In 1859, the Collection had become so extensive from gifts, especially at the Exhibitions in London and Paris, that the Classified Catalogue formed a most useful book of reference on the subject, and was largely sold as such. I have a specimen of it here (*producing the same*). The Commission will see that a great part of that Catalogue at the end consists of a very elaborate set of experiments which were made on the strength of materials, especially on the various Woods from the Colonies which were exhibited in the London and Paris Exhibitions; and in some cases that set of experiments has had a very great effect on the trade in woods of some of the Colonies, some of the woods having been then shown to possess very good qualities, they have come largely into use. A revised edition of the Catalogue was issued in 1860. The collection consists of the following objects:—building stones, marbles and slates, cements and plasters, bricks of every description, tiles for roofing, flooring, and wall decoration, terra cotta, drain pipes, asphalte and bitumen, iron and metal work, woods applicable to building purposes, glass, and its application, models of buildings and construction, paperhangings, papier-mâché work, architectural drawings and plans. These Collections are now exhibited in the Southern arcade of the Horticultural Gardens. We have no room for them in the Museum at South Kensington, and they have been taken over to the arcade, and are exhibited there at present. This is a very important Museum, and it has been largely consulted by persons engaged in the building trades, by architects, builders, and others. I may mention that I think the recent revival of the

Maj. J. F. D. Donnelly, R.E.

21 Nov. 1873.

use of both concrete and terra-cotta in building is largely due to the examples shown in the Structural Museum.

13,845. What is the next Collection to which you wish to call our attention? — The Collection of Marine Engines and Models of Ships, Guns, War Material, and things of that kind. That collection was formed in connection with the Royal School of Naval Architecture and Marine Engineering. A large proportion of the naval models were sent to South Kensington from the Admiralty. The naval models belonging to the Admiralty have been removed now to Greenwich; but a number of the models of ships and all the war material exhibited by the War Office still remain at South Kensington. A number of models were given to the South Kensington Museum on the condition that they should not go away. As a specimen of the objects generally interesting and not special to war purposes, I may mention that we have a series of models illustrating construction according to Lloyd's Rules. There are, also, some very fine models of Marine Engines. In addition to these Naval Models, there are a number of models and pieces of machinery which have come into the Department at different times, such as models of the Jacquard loom, the Whitworth measuring machine, Babbage's calculating machine, and a number of things of that kind which have formed part of this Collection, and are of course now still at South Kensington.

13,846. Have you any suggestion to make with respect to the extension of a Museum of this class?—I think that with those models and with the models in the Patent Museum, and others that would no doubt be very soon added to the collection by gift, and a few that it might be necessary to purchase, it would be of the very first importance to commence, as soon as possible, a Museum somewhat on the principle of that of the *Conservatoire des Arts et Métiers*.

13,847. Have you room for it?—Not in the South Kensington Museum itself. I should say that I think the Patent Museum will have to be moved very shortly to make room for more permanent buildings for the Science and Art Department, and I would suggest that the Collections belonging to the Patent Museum, and those I have just mentioned as belonging to the South Kensington Museum, should be housed and displayed in that central portion of the Southern arcades of the Horticultural Gardens which was used as a refreshment room for the Exhibition of 1862. It belongs to the Commissioners of the Exhibition of 1851, but, I believe, they would sell it or rent it to the Government, and it would be very available for the commencement of such a Museum as this. The arcades on each side of this centre building and connecting it with the road on each side, belong to the Government, so that all that is really necessary is to arrange with the Commissioners to purchase this building or to rent it.

13,848. Would you include in such a Museum, machines illustrating the progress of Industrial Invention in the principal manufactures of the country?—Yes; but I think that the Museum should not be looked upon as a Museum of Patents, it should be a Museum to illustrate the Mechanical Arts. A Museum of Patents, as I think the Committee of the House of Commons in their Report upon it show, is to a great extent a farce. The present Museum is not a Museum of Patents in any proper sense. Nor would it be any use if it were. You never would refer to it in making investigations about *patents*; you refer to it for the purposes of general mechanical art, and the principal and most useful parts of it are very often things that are not patented, or of which the patents have long run out; as, for instance, the early steam engines, and various applications which are no longer matters of patent.

13,849. To take one example, you would think it desirable, would you not, to have a Collection showing the Progress of Invention from the Loom with the hand-thrown shuttle up to the Jacquard Loom and the Electric Jacquard?—Yes, but quite irrespective of any question of patenting.

13,850. (*Professor Huxley.*) If such a Museum had ever existed, do you think that it would have received accessions by way of presents?—I think it would have received enormous accessions. It must be such an obvious advantage to a manufacturer to exhibit anything in it, that he would, I should think, be only too glad to get it admitted. The difficulty would probably be more in excluding than in obtaining objects.

13,851. (*Chairman.*) Do not such collections as I have hinted at in the question that I have put with respect to the history of the loom exist in the *Conservatoire des Arts et Métiérs* of Paris?—Yes. We have, I may mention, belonging to the South Kensington Museum, the original model of the Jacquard Loom.

13,852. What is the next Collection at South Kensington?—The next is the Collection of Economic Entomology and Forestry. This collection, which is now in course of formation under the Superintendence of Mr. Andrew Murray, is intended to enable the public to distinguish insects injurious to man from those that work to his advantage, and to illustrate the best means of destroying those considered injurious, or of mitigating the ravages often committed by them. The insects are shown in various stages of growth, either by drawings, models, or preserved specimens. Gardeners' foes are shown side by side with gardeners' friends, together with the plants and fruits on which they feed. The Collection illustrating Forestry shows the various kinds of timber attacked, the insect in various stages of growth, the appearance of the foliage and bark when attacked, and the best known means for destroying the insects.

13,853. Is there any good Manual attached to that Collection by which a gardener, without any considerable scientific knowledge, can make himself acquainted with the subject?—I am afraid it has not yet been made, but I have no doubt that there will be one made very shortly. It would be a most useful work to get out.

13,854. There are many men of great sagacity in charge both of forests and of gardens who have little or no scientific knowledge, and to whom such a Manual would be very useful, would it not?—Yes.

13,855. What is the object of the Fish Culture Collection?—In the arcades that I was speaking of a little time ago, on the other side of the road, at the bottom of the Horticultural Gardens, there is the Museum of Fish Culture. This is a Collection illustrative of the artificial breeding of fish, the protection of rivers, methods of capture of fish, &c. It is rather of an exceptional nature, for all or nearly all the Collection belongs to Mr. Buckland. It is on loan to the Museum, which houses it and pays for attendants, water, and that kind of thing. Mr. Buckland also receives an honorarium of 100 guineas a year for his services in connexion with it and in keeping it up.

13,856. What have you to say with regard to the Patent Museum?—This collection does not belong to the Department of Science and Art; it belongs to the Commissioners of Patents. It is housed in a part of the old iron buildings of the South Kensington Museum, which is much too small for it. It has been there since the opening of the Museum in 1857. There is a separate entrance to this Museum distinct from the general entrance to the South Kensington Museum, and the public are admitted free daily. When the South Kensington Museum was first opened, the public came through the Patent Museum into the rest of the Museum, that is to say, the general entrance was at the front of the Patent Museum. The Patent Commissioners, however, thought that the arrangement we have at the South Kensington Museum for keeping three days in the week for students' days, admitting the public at a charge of 6*d*., was not in accordance with the understanding with which they had received many of their models; they had some

Maj. J. F. D. Donnelly, R.E.

21 Nov. 1873.

objections to that system, and they would not consent to it. They required a separate entrance, and so a separate entrance was made. Of course it is very inconvenient for people coming to the Museum, because they have to go round and out into the road to get into the Patent Museum. The Patent Museum is heated and lighted by the Science and Art Department, and the Science and Art Department is responsible for the custody. The collection itself is under the officers of the Commissioners of Patents, who make any additions to it that they think fit. At the present moment it is quite choked up. I think there are passages which are only 14 or 15 inches wide. It is a most extraordinary sight to go into it. I regret I could not get a Catalogue to bring with me, as it is out of print, but it has some very interesting objects, especially specimens of the early steam engines.

13,857. Have you any conception of the mode in which the Collection of Mechanical Inventions might be made useful to teachers?—I think it would not only be useful to the people who went to the Museum, but it would also be directly useful in the work of the Science and Art Department in this way. The Professor of Applied Mechanics has been transferred from Jermyn Street to South Kensington, and his instruction will in future be given there. I think it would be of immense use to him if he were able to send his students across the road to look at any particular machinery, to make drawings of it, and to receive demonstrations on the use of it. He has now, of course, a certain number of models, but the collection we can find space for, in the few rooms disposable, is very small, and is of very little use in comparison with a collection such as this might be. When we have had classes of Teachers in London, a great part of the Professor's instruction has consisted in taking them to different places in and about London, where they could see machinery of different kinds, and explaining the machines to them on the spot. It is sometimes said that a Collection of this kind would become of prodigious size, quite unmanageable, and useless. So it would if it were a Collection of Patents, as such. But this would be a great mistake. The objects should not be admitted as patents. The Collection should be formed and maintained with the definite object of Instruction in Applied Mechanics. If you kept a collection of that kind properly weeded, you need not have much space. Again, it is sometimes said that diagrams will do as well as the objects themselves, or as models. But take the ordinary case of a professor or lecturer on Applied Mechanics,—he never likes to content himself in his lectures with diagrams only. He has generally pieces of working machinery or models. He can bring home to a student from bits of working machinery in a minute such matters, for instance, as complex movements, of which it would be very difficult to convey a correct knowledge by diagrams. In his lectures, again, on the Steam Engine, a lecturer always begins with an historical sketch of the Steam Engine, and gives you its early forms, and points out how improvements came to be made. He can show that at once if he can direct the student to such specimens as Watts' "Sun and Planet" Engine, which the Patent Museum contains. I suppose no man ever began to lecture on the Steam Engine without giving a description of that engine, and there is the thing itself. I think, in fact, that the Collection at South Kensington should be very much of the same character as a lecturer would like to be able to show in going through his lectures on machinery.

13,858. Will you state to the Commission what action has been taken upon the Report of the Commission on the Science and Art Department in Ireland?—Generally speaking, none at all. One or two small details have been carried out, such as the removal of the Offices of the Geological Survey from the College of Science in Stephen's Green, Dublin, to a house adjacent, so as to make more room for the College of Science; but beyond that I do not think anything has been done.

13,859. Would you be kind enough to furnish the Commission with a detailed account of the expense which is incurred by the Government connected with Science with respect to Museums and Public Botanic Gardens, &c., in Dublin and in Edinburgh?—The several amounts granted for 1873–4 were—

	£
For the Staff of the Royal Dublin Society	2,268
For the Botanic Gardens (Dublin), including Leinster Lawn	2,353
For the Museum of Natural History -	1,678
For the Royal Irish Academy	2,084
For the Library (Dublin) -	1,708
For the Museum of the Royal College of Science* -	300
[*For the Purchase of Specimens, the amount required is included in a sum of 900*l.* taken for the Purchase of Specimens, Outfit and Illustrations for Lectures, and Books for Library, &c.]	
For the Edinburgh Museum of Science and Art	9,231 6*s.*
The Edinburgh Botanic Garden -	1,750

13,860. Is there any other point upon which you think it desirable to give information to the Commission?—I do not remember anything further.

The witness withdrew.

Adjourned.

APPENDICES.

LIST OF APPENDICES.

Page

APPENDIX I. (See Question **1446,** Vol. I., p. 87.)
  Appendix to the Evidence given by Professor Henry. (See Vol. I., pp. 84–92.) - 1

APPENDIX II. (See Questions **4700–4818,** Vol. I., pp. 300–304.)
  Statement by the Professor of Zoology and Comparative Anatomy in the University of Cambridge 1

APPENDIX III.
  Correspondence relating to the First Report of the Royal Commission on Scientific Instruction and the Advancement of Science; and a Memorial addressed to the Department of Science and Art by the Director of the Royal School of Mines 2

APPENDIX IV.
  Correspondence between Her Majesty's Commissioners and the Warden of the University of Durham 5

APPENDIX V.
  Correspondence between Her Majesty's Commissioners and the Heads of the Scotch and Irish Universities 5–19
    University of St. Andrew's 5
    University of Glasgow - 7
    University of Aberdeen - 7
    University of Edinburgh - 8
    University of Dublin - 16
    The Queen's University in Ireland - 17–19
      Queen's College, Belfast 17
      Queen's College, Cork - 18
      Queen's College, Galway 18

APPENDIX VI. (See Questions **13,371, 13,372,** Vol. II., p. 325.)
  Catholic University of Ireland:—Exhibitions and Prizes to be competed for during the year 1872 20–25
  On Cramming for Examinations, &c. - - - - 25–27

APPENDIX VII. (See Questions **10,316-17,** Vol. II., pp. 75, 76.)
  Communications from Lieutenant-Colonel Alexander Strange, F.R.S., and Professor Cayley, F.R.S., relating to the proposed Establishment of a Physical Observatory 27–31

APPENDIX VIII. (See Question **10,522,** Vol. II., p. 97.)
  Remarks on the History and Position of the (now abolished) Board of Longitude. By Sir G. B. Airy, K.C.B., F.R.S., Astronomer Royal, formerly Member of the Board - - - 31

APPENDIX IX. (See Question **10,689,** Vol. II., p. 108.)
  Memorial to the Right Honourable the Lords Commissioners of Her Majesty's Treasury respecting Tidal Observations 32

APPENDIX X.
  Communications from George Gore, Esq., F.R.S., Edgbaston, Birmingham 33–41

APPENDIX XI.
  Correspondence of Her Majesty's Commissioners with General Sir Edward Sabine, R.A., K.C.B., as President of the Royal Society, respecting the Government Grant to the Council of the Society in Aid of Scientific Research 41–62

APPENDIX XII.
  Paper handed in by John Anderson, Esq., C.E., LL.D., Superintendent of Machinery to the War Department, and Examiner in Applied Mechanics, Science and Art Department, South Kensington 62–64

APPENDIX XIII. (See the Evidence of Mr. Buchan, Vol. II., pp. 245–250.)
  Communication from the Scottish Meteorological Society - 64–67
  Communication from the Board of Trade 67

APPENDIX XIV. (See the Evidence of Mr. Milne-Home, Vol. II., pp. 250–261.)
  Memorial of the Council of the Royal Society of Edinburgh 67–70

APPENDIX XV. (See Questions **12,535-12,538,** Vol. II., pp. 260, 261.)
  Petition of the Council of the Geological Society of Edinburgh - 70

APPENDIX XVI.
  Letter from the Honourable Mr. Justice Grove, F.R.S. 71

APPENDIX XVII.
  Scientific Instruction in Germany:—Communication from Professor Hofmann, F.R.S. 71

APPENDICES.

APPENDIX I. (See Question **1446.**)

APPENDIX to the EVIDENCE given by PROFESSOR HENRY. (Vol. I., pp. 84–92.)

[Information referred to in question 1446, Vol. I., p. 87, and since furnished by Professor Henry.]

Appropriations by the United States Congress. made at the Session of 1869–70, *for the ensuing year, July* 1*st*, 1870, *to June* 30*th*, 1871, *in aid of Science, Literature, etc.*

[It should be observed that the following appropriations are those of the General Government and not those of the separate States, which in the aggregate would far exceed the amount here presented.]

1. MUSEUMS:—		
National Museum in charge of the Smithsonian Institution	$20,000	
Army Medical Museum -	5,000	
Agricultural Department Museum -	8,000	
		33,000
2. BOTANIC GARDENS AND GREENHOUSES:—		
Of the United States' Capital	35,996	
„ President's House -	2,500	
„ Agricultural Department - -	38,200	
		76,696
3. AGRICULTURE:—		
Department of Agriculture Mixed Expenses -	138,070	
		138,070

To this is to be added from items already given—

Botanic Gardens and living plants	38,200
Museum -	8,000
Library -	3,800
	$50,000
Or an aggregate of -	$88,070

4. ASTRONOMY AND METEOROLOGY:—		
Observations of Eclipse, December 1870, under Coast Survey - -	$29 000	
United States Nautical Almanac	20,000	
National Observatory -	19,800	
New Telescope for National Observatory - -	50,000	
Telegraphic Notice of Storms -	50,000	
		168,800
5. SURVEYS, ETC.:—		
United States' Coast Survey	703,000	
Survey of Lakes -	150,000	
„ Nicaragua and Tehuantepec Ship Canals -	30,000	
Military Surveys West of Mississippi	100,000	
Professor Powell's Survey of the Colorado of the West - - -	12,000	
Polar Explorations -	50,000	
Dr. Hayden's Geological Survey -	25,000	
Statistics of Mines and Mining - -	10,000	
		1,080,000
6. LIGHTHOUSE ESTABLISHMENTS - -	1,431,207	
		1,431,207
7. LIBRARIES:—		
Library of Congress -	$36,220	
Of Medical Department of the United States' Army - - -	3,000	
„ Agricultural Department	3,800	
		43,020
8. EDUCATION:—		
United States' Department of Education - -	14,500	
Wilberforce and Lincoln Universities - -	37,000	
		51,500
9. BENEVOLENT OBJECTS:—		
Life Boat Service on the Coast - - -	$48,880	
Government Hospital for Insane - - -	149,980	
Columbia Institution for Deaf and Dumb -	40,775	
Columbia Hospital for Women - -	18,000	
National Association for Destitute Colored Women, D.C. - -	10,000	
National Soldiers' and Sailors' Home, D. C.	15,000	
Care of 60 Transient Paupers -	12,000	
		294,635
Total -	-	**$3,316,928**

APPENDIX II. (See Questions **4700–4818**, Vol. I., pp. 300–304.)

STATEMENT by the PROFESSOR of ZOOLOGY and COMPARATIVE ANATOMY in the UNIVERSITY of CAMBRIDGE.

SIR, Cambridge, Dec. 3, 1870.

REGARD to my duties in the University, which have of late been very pressing, has hindered me from sooner complying with the request contained in your letter of the 30th November.

As to the evidence which I shall be prepared to submit to Her Majesty's Commissioners on the 6th inst., the short notice I have received of their wish to examine me, coming towards the end of a Term throughout which I have been most laboriously occupied, will compel me to be very brief. I hope, however, to furnish the Commissioners with a statement showing the sums of money expended by the University in support of the Museums of Zoology and Comparative Anatomy, as well as of the amount raised towards the same end by subscription from members of the University in their individual capacity.

The point on which I shall chiefly dwell is, that the promotion of the sciences which are committed to my charge is mainly if not entirely a question of money. So far as I have been able to gather, there are now few, if any, residents in the University who would not gladly see it supporting liberally those sciences among others, if the means were but at its disposal. There exists, however, it seems to me, a feeling that the property of the separate Colleges ought not to be devoted to the encouragement of Studies which were not contemplated in the framing of their Statutes, even as these stand after recent alterations. It is this feeling (of which, perhaps, those who possess it are themselves hardly conscious) that really hinders, I suspect, the common action of the Colleges in aiding, from their several resources, any comprehensive scheme. Without professing a particular knowledge of the finances of the University, I am persuaded that, if the study of the Natural Sciences is to be placed on an effective footing, it must be done by means of the Colleges, either collectively or separately; but I cannot take upon myself to declare which I should prefer, of various suggestions which have from time to time been made, such, for instance, as the abolition of sinecures, or quasi-sinecures, or the incorporation with, or affiliation to, the Colleges of certain University Officers. I fear, however, that whatever changes be expedient, they will hardly be made without recourse being had to external pressure.

To return to my own subjects, I can say that we are lamentably deficient in provision for their due prosecution in our Museums. The Superintendent as well as myself have frequently to perform work which might as well be done by an intelligent lad, especially instructed, and this at a loss of time which we could devote to the interests of the University in a far better way. Our collections have lately become so important, that the appointment of a Curator, particularly in the Zoological Museum, is absolutely necessary for the cataloguing and keeping in due order of the specimens, and for the assisting of students—whether Members of the University or strangers—of whom the number is steadily increasing, *the Museums being open to all comers.* Fittings are still urgently needed in both museums, and for the Students of Comparative Anatomy the appointment of a demonstrator, a separate dissecting room, and further accommodation are required. At the same time, I should be conveying a very erroneous impression if I omitted to acknowledge that with all existing shortcomings our progress since 1863, when the new Museums were begun, has been uninterrupted, and, considering the amount of opposition which had to be overcome, marvellous.

With regard to my own office, I think that, looking to the enormous range of the subjects I am required to teach, it would be of great advantage to the University if those subjects could be divided, and a second Professorship founded. And, finally, I would observe, that though I have no doubt as to the benefit which would accrue to the University by freely opening to Students of the Natural Sciences the honours and emoluments of the Colleges, I am by no means so certain that a corresponding benefit would thereby be derived by Science itself.

I have, &c.
ALFRED NEWTON.

The Secretary,
Aid to Science Commission.

APPENDIX III.

CORRESPONDENCE relating to the FIRST REPORT of the ROYAL COMMISSION on SCIENTIFIC INSTRUCTION and the ADVANCEMENT of SCIENCE; and a MEMORIAL addressed to the DEPARTMENT of SCIENCE AND ART by the DIRECTOR of the ROYAL SCHOOL OF MINES.

I.—LETTER, with Enclosures, addressed to the ROYAL COMMISSIONERS.

Science and Art Department, London, W.
May 23, 1871.

SIR,

I AM directed by the Lords of the Committee of Council on Education to forward to you the accompanying copy of a statement of the opinions of some of the Professors of the Royal School of Mines on the First Report of the Royal Commission on Scientific Instruction, with a copy of the letter from Sir Roderick Murchison transmitting the same; and I am to say that their Lordships do not propose to take any steps with respect to these communications until they have heard from the Commissioners.

I am, &c.
NORMAN McLEOD,
Assistant Secretary.

The Secretary,
Royal Commission on Scientific Instruction
and the Advancement of Science,
Old Palace Yard.

(Copy).

Jermyn Street, April 22, 1871.

SIR,

I ENCLOSE, for the consideration of the Lords of the Committee of Council on Education, a statement of the opinions of those Professors of the School of Mines whose teachings are most intimately connected with the well-being and efficiency of that establishment.

I have on more than one occasion informed their Lordships that in my opinion it was essential to the success of the School of Mines that it should be ever kept in connexion with the Geological Survey and Museum in Jermyn Street; and I, therefore, entirely approve of the enclosed document, though I beg to state that I have taken no part in its preparation.

Having now presided for very nearly 16 years over the Council of Professors or Teachers of the School of Mines, I am bound to state that we have invariably acted in perfect harmony; and after the proofs we have obtained of the successful labours of the eminent men over whom it has been my pride to preside, it would truly grieve and mortify me to see this compact body, whose duties and objects are so well defined, losing its special *mining* character, by being moved from its present central position, and absorbed in a general "College of Science."

I am, &c.
(Signed) ROD. I. MURCHISON.

The Secretary,
Department of Science and Art.

(Copy.)

Royal School of Mines,
April 22, 1871.

SIR,

WE, the undersigned officers of the Museum of Practical Geology, and some of us lecturers in the Royal School of Mines from its commencement, having read the "First Report of the Royal Commission on Scientific Instruction, &c.," have the honour to submit to you our opinions on certain recommendations contained therein which affect the Royal School of Mines.

The Commissioners propose to remove the teaching department, termed the "Royal School of Mines," in Jermyn Street, to South Kensington, to be there merged in what they designate a "Science School." While we admit that "there is no necessary connexion between the "direction of the Geological Survey and of the School of "Mines," we nevertheless hold it to be indisputable, that considering the special object for which that school was established, the direct association of the two institutions has been attended with great practical advantage. The object of the Geological Survey is the investigation of the nature and extent of the mineral resources of the country; and the object of the Royal School of Mines is to teach how those resources may be most scientifically, and, therefore, most efficiently and most economically, developed. But in order that the teaching may be as practical as possible, it is not only desirable, but essential, that the teachers should be able to avail themselves of suitable and extensive collections, such as have been accumulated in the Museum of Practical Geology. And if this be admitted, it follows, obviously, that the museum and the school should be localized in the same building, and that they should not, as proposed in the First Report of the Royal Commissioners on Scientific Instruction, &c., be separated from each other.

It may here be advisable to state succinctly how the School of Mines originated.

During the execution of the Geological Survey, commenced many years ago by the Government, and still in progress, large and valuable collections have been made illustrating the nature and extent of the various geological formations, and the methods by which the minerals contained in them may be turned to practical account.

By a parliamentary vote during the administration of the late Sir Robert Peel, strongly advocated by the late Mr. Joseph Hume, it was determined that a suitabe building should be erected, in which to preserve those collections, and to which there might be free access, for examination and study, to persons concerned in mining, quarrying, metallurgy, civil engineering, architecture, and agriculture, as well as to the general public. It was further decided by the Treasury, in pursuance of a recommendation of the British Association in 1838, to establish a "National "Depository for the preservation of documents and records "relating to the mining operations of the country," in which to collect plans of existing and of abandoned mines, partly for the preservation of human life, and partly to guard against the waste of capital upon mining enterprises in ground previously exhausted.

Hence the Museum of Practical Geology and a Mining Record Office in association therewith were established.

Such an institution being in existence, it was represented to the Government in numerous memorials from the mining districts, particularly Cornwall, South Wales, Staffordshire, Northumberland, and Durham, that it was desirable further to utilize its collections by the establishment of courses of lectures in the museum, and hence arose, in 1851, the School of Mines. The institution did not conflict with any other, because no school of the kind existed in this country; and it is notorious that students desirous of acquiring a knowledge of the subjects taught in this school were obliged to visit distant foreign academies for the purpose.

We would remind you that there is a wide distinction between a school for preparatory training in the elementary sciences, and a school designed for teaching the application of those sciences to any particular industrial art. The object of the former is general, while that of the latter is special. Excellent instruction in the elementary sciences, such as mathematics, chemistry, physics, &c., a knowledge of which is indispensable to the students of a school of mines, is provided in numerous private institutions, both in the metropolis and in other parts of the kingdom; and some of the students of the Royal School of Mines have received their instruction in those branches of science at such institutions.

We are apprehensive that if the Royal School of Mines be merged in a general science school it may lose its definite and distinctive character, and that the confidence of the mining interest in its value, which we have so long struggled to acquire, may in consequence be severely shaken. We fear, moreover, that the cause of technical instruction in the mining districts, the subject of so many applications to Government, and of so many observations by Committees of the Houses of Parliament, and by the Government Inspectors of mines in their reports on the loss of life in mining operations, would, by such a course as is now proposed, be thrown back for many years

The value of the juxtaposition of these collections of the geological maps, mining plans, statistical documents, and mining models, and of the metallurgical laboratory, has been attested by the great number of persons, including the present Prime Minister and numerous members of Parliament, and officers of public departments, who have sought for special information concerning the mineral resources and geological structure of particular districts of the country. It is of no slight importance that these collections are placed in a part of London so easily accessible to official and commercial men.

Amongst the reasons assigned for the recommendation to transfer the Royal School of Mines to South Kensington is that of deficient accommodation in the existing institution. The Keeper of the Mining Records, whose evidence has not been requested by the Commissioners, asserts that there is ample accommodation for additional records during many years to come, notwithstanding it is alleged by the Commissioners, in their First Report, that "the space allotted to "the Mining Record Office is already insufficient for the "proper reception and arrangement of the valuable docu-"ments accumulated there." The Lecturer on mining and mineralogy declares that he is perfectly satisfied with the space devoted to his department. The Lecturer on geology, as such, requires no increase of space; but, as Director of the Geological Survey, he needs additional room, which might easily be provided, at a comparatively small cost, in the immediate vicinity of the collections which have to be so frequently consulted. The Lecturer on metallurgy thinks it desirable somewhat to increase the dimensions of the metallurgical laboratory for the practical instruction of the students in assaying, as he has been repeatedly obliged to decline the application of students for admission from want of space; but this may be obtained in the existing institution at a very small outlay compared with what would be necessary in the event of removal to South Kensington. With regard to the absence of a biological laboratory we have no observation to offer, because we hold that such a laboratory has no connexion with a school of mines; and there is not a mining school in the world, so far as we are aware, in which biology forms part of the instruction.

With regard to the following paragraph in the First Report of the Commisioners,—"The Royal School of "Mines and the Royal College of Chemistry, which "practically constitute one school of pure and applied "science, are not organised in such a manner as to enable "them to perform efficiently the work for which they were "originally, or are at present, intended,"—we would submit, that, as the teachers of subjects which are everywhere considered the essential basis of a mining school, our opinions, as to the requirements necessary for efficient teaching, are deserving of consideration.

The Royal School of Mines is, we maintain, in a most favourable condition for its effective working. It is in a most convenient and accessible locality; it has at its command copious illustrations of fossils, minerals, ores, rocks, and mining and metallurgical models, many of which are so large as not to admit of occasional removal; it is provided with laboratories for the examination and analysis of mineral products, and for instruction in the art of assaying; a large and valuable collection of mining plans, and an extensive library especially bearing on the subjects of its teaching, are in immediate connexion with it; it is constantly resorted to by persons engaged in mining, metallurgical, and engineering enterprise, its locality is well known throughout the country, and the fact of the public having been accustomed to this locality during more than 20 years is a consideration of importance. Under these circumstances, we are of opinion that if the proposals of the Commissioners respecting it be carried out its utility will be greatly diminished, if indeed its existence be not thereby jeopardized. The removal of the school to South Kensington would be attended with considerable expense to the nation, for which we see no justification in the reasons assigned by the Commissioners for their proposals. Having laboured during so many years to render the institution worthy of the confidence of the country, and perceiving, as we think, that at length our labours have not been in vain, we are naturally anxious to act upon the let-well-alone system, especially as the school has never been more prosperous than of late.

In conclusion, we would add that we have reason to know, both from published statements and from personal communications at home and abroad, that the juxtaposition of the various branches of the establishment in Jermyn Street, under your direction, has met with the cordial approval of eminent persons engaged in the teaching and practice of mining, and the allied pursuits, in various parts of Europe and America; and that the institution in its present form has been reported on by them as a classical example, and a model for the organisation of similar schools at Berlin, Vienna, New York, and other places.

We have, &c.

(Signed) WARINGTON W. SMYTH, M.A., F.R.S.,
Lecturer on Mining and Mineralogy.

ANDW. C. RAMSAY, LL.D., F.R.S.,
Lecturer on Geology, and Director of the Geological Survey of England.

JOHN PERCY, M.D., F.R.S.,
Lecturer on Metallurgy at the Royal School of Mines, and to the Advanced Class of Artillery Officers at the Royal Artillery Institution, Woolwich.

ROBERT HUNT, F.R.S.,
Keeper of Mining Records.

To Sir Roderick I. Murchison, Bart., K.C.B.,
Director General of the Geological Survey,
&c. &c. &c.

II.—REPLY of the ROYAL COMMISSIONERS.

Royal Commission on Scientific Instruction
and the Advancement of Science,
6, Old Palace Yard, S.W., July 19, 1871.

SIR,

IN reply to your letter of the 23rd of May last, I am requested by the Duke of Devonshire, the Chairman of this Commission, to transmit herewith the Report of a Committee of this Commission to which the enclosures in your letter were referred.

I am to add that this Report was received and adopted by the Commission at a meeting held yesterday.

I remain, &c.
(Signed) J. NORMAN LOCKYER, Secretary.

The Secretary,
Department of Science and Art.

REPORT referred to in the foregoing Letter.

1. In compliance with the reference of the Commission, the Committee appointed on the 3rd of March 1871 have considered the memorial of three Professors of the School of Mines and of the Keeper of Mining Records, and the letter from Sir Roderick I. Murchison, transmitting the same, which have been referred to the Commission by the Lords of the Committee of Council on Education.

2. In the First Report of the Commission (in addition to other recommendations not directly affecting the questions raised in the memorial), it was recommended, in effect, that the Royal School of Mines and the Royal College of Chemistry should be consolidated, and that the consolidated institution should be accommodated in the new buildings at South Kensington.

3. In connexion with this recommendation, it was proposed, That the building in Jermyn Street be given up to the Survey and to the Museum, with the reservation that the lectures to working men be delivered as heretofore in the theatre; that the building in Oxford Street be vacated by the Royal College of Chemistry; that the Mining Record Office be lodged with the Statistical Department of the Board of Trade, or, failing accommodation there, in the building now occupied by the Royal College of Chemistry; and that the theoretical instruction of the Royal School of Naval Architecture and Marine Engineering be in future given in the Science School, the general instruction in mathematics, physical science, and mechanical drawing becoming common to both schools.

4. These recommendations were based on the considerations stated in the First Report of the Commission, and are supported by evidence given before the Commission, before the Committee of the House of Commons on Scientific Instruction, and by official letters and reports of the Officers of the Geological Survey, and of the Professors of the Royal School of Mines, including some of the memorialists themselves, bearing on the following points:

- a. The want of room in the existing Government buildings in Jermyn Street and Oxford Street for the various departments established there, even under the present conditions of teaching.
- b. The absence of instruction in pure and applied mathematics in the School of Mines, and the facility afforded for supplying such instruction by connecting it with the Royal School of Naval Architecture and Marine Engineering.
- c. The need of better provision for giving practical instruction in physics, chemistry, and biology.
- d. And the advantage generally of concentrating in one place the several courses of instruction given in the Schools.

5. The Memorial on which we have been requested to report objects to these recommendations mainly on the following grounds:—

I. That they involve great expense to the nation, and that the additional accommodation required can be obtained in Jermyn Street at a moderate cost.

In reply to this, the Committee have to state that it is in evidence that the cost of extension in Jermyn Street would be very great; whereas the Government possesses a building at South Kensington affording all necessary accommodation.

II. That it is not desirable to separate the Mining School proper from the other departments now situated in Jermyn Street.

On this the Committee would observe that it is impossible, without great cost, to retain even this department of the School in immediate contiguity to the Geological Museum and Survey. The consolidation of the School is, moreover, in the opinion of the Committee, of greater importance than such contiguity. The evidence given before the Commission shows more especially that there is a great disadvantage in dissociating the chemical laboratory from the geological and metallurgical work. It has long been felt to be a defect, that the Royal College of Chemistry, though a department of the Royal School of Mines, is not in the same building with the other classes of that school.

III. That if the Royal School of Mines be merged in a general science school, it may lose its definite and distinctive character, and that the confidence of the mining interest in its value, which the Professors have so long struggled to acquire, may in consequence be severely shaken.

In reference to this objection, the Committee have to state that for the last 18 years the average number of students, who, having been examined in mining or mineralogy, have subsequently been employed in the Geological Survey and in the mines and metal works of the United Kingdom, has, according to a table put in evidence, been less than four per annum; and if, notwithstanding the eminence of the Professors, the mining interest has been very slow to avail itself of the advantages afforded by the School, this may be owing in a great degree to the imperfection of its organization, and to the incompleteness of the preparation which it supplies for the professions of mining and metallurgy, owing to the entire absence of instruction in mathematics, and, as a necessary consequence, imperfect teaching of applied mechanics and machinery. The Committee believe that these defects will be in a great measure remedied by the proposed association of the School of Mines with that of Naval Architecture and Marine Engineering; and that the appreciation of the technical education afforded in the school, far from being diminished, may fairly be expected to increase.

IV. That "it is not only desirable but essential that the "teachers should be able to avail themselves of "suitable and extensive collections, such as have "been accumulated in the Museum of Practical "Geology."

The Committee admit the force of this objection, but cannot allow it to outweigh the other considerations referred to above, on which the decision of the Commission has been based. At the same time they have learnt that the specimens belonging to the Museum are very rarely exhibited in the lecture rooms; and they believe that whilst the Museum would still remain accessible for study, one or more collections on a smaller scale, adapted for the illustration of lectures, could without difficulty be provided for the school.

V. That the recommendation as to the removal of the Office of Mining Records is unnecessary and based upon insufficient evidence.

The Committee would state that the removal of the Office of Mining Records is a secondary question. Owing to the illness of the Keeper the Commission was unable to examine him, and its recommendation was based on the evidence of other witnesses holding office in the establishment in Jermyn Street. If arrangements can be made between the Record Office and the Geological Survey for the continued accommodation of the former, without the erection of new premises, there would certainly be considerable convenience in keeping these two departments under the same roof.

6. The Commission will observe, from the annexed letter of Professor Huxley, a member of this Committee, that in consequence of his holding office as a Professor of the Royal School of Mines, he has preferred not to take any part in the deliberations of this Committee on the subject of this Report.

B. SAMUELSON.
W. SHARPEY.
HENRY J. S. SMITH.

J. Norman Lockyer, Secretary.
July 18th, 1871.

APPENDIX.

DEAR MR. SAMUELSON,

As I am a member of the Committee (of which you are Chairman) to which the Aid to Science Commission has referred a letter addressed to the Government by the Director and three of the Professors of the Royal School of Mines, I desire to say that I do not well see how I (as a Professor in the Royal School of Mines) can properly take part in the discussion of that letter by the Committee.

I therefore propose to absent myself from the meetings of the Committee so long as it is occupied with the subject in question.

I am, &c.
T. H. HUXLEY

June 3rd, 1871

APPENDIX IV.

CORRESPONDENCE between HER MAJESTY'S COMMISSIONERS and the WARDEN of the UNIVERSITY OF DURHAM.

The following letter was addressed on the 27th of June 1870, to the Very Rev. The Dean of Durham, as Warden of the University :—

6, Old Palace Yard, Westminster, S.W.
VERY REV. SIR, June 27th, 1870.

I HAVE the honour to inform you that Her Majesty has appointed Commissioners to make inquiry with regard to Scientific Insrruction and the Advancement of Science, and to inquire what aid thereto is derived from grants voted by Parliament or from Endowments belonging to the several Universities in Great Britain and Ireland and the Colleges thereof, and whether such aid could be rendered in a manner more effectual for the purpose.

The Royal Commissioners are of opinion that the inquiry with which they are charged will be much facilitated by their being speedily placed in possession of authoritative statements, on behalf of the several Universities and Colleges indicated in their Commission, of the aid to Scientific Instruction and the Advancement of Science derived from Parliamentary grants and from endowments which they enjoy.

I am therefore directed to request that you will have the goodness to furnish the Commissioners with a statement of all sums applied to the Advancement of Science or to Scientific Instruction in the University of Durham which are derived from endowments or from Parliamentary grants.

This information will be useful to the Commissioners in proportion as these endowments and grants and their applications are specified in detail.

I am further to state that the Commissioners will be glad to receive suggestions or to hear evidence from you in respect of the matters into which they are commanded to make inquiry.

I have, &c.
J. NORMAN LOCKYER,
Secretary to the Commission.

The following reply was received :—

Deanery, Durham,
SIR, June 29, 1870.

I BEG to acknowledge the receipt of a letter yesterday from you, as Secretary to the Royal Commission on Scientific Instruction, with regard to the endowments in this University which are devoted to the Advancement of Physical Science. I hope to supply you in a few days with a detailed account of such endowments, but answer your note at once in order to express my willingness, by evidence or otherwise, to further the object of the Commission, which is of especial importance in the North of England.

I am, &c.
J. Norman Lockyer, Esq., W. C. LAKE.
Secretary, &c.

[The "detailed account" promised in the above letter has not been received. See, however, the Evidence given by the Dean of Durham, qu. 8757–8841, pp. 599–604, Vol. I.]

APPENDIX V.

CORRESPONDENCE between HER MAJESTY'S COMMISSIONERS and the HEADS of the SCOTCH and IRISH UNIVERSITIES.

[A similar letter to that addressed to the Warden of the University of Durham (see Appendix IV. p. 5), was sent in June 1870 to the Vice-Chancellor of the University of St. Andrews, the Vice-Chancellor of the University of Glasgow, the Principal of the University of Aberdeen, the Vice-Chancellor of the University of Edinburgh, the Vice-Chancellor of the University of Dublin, the Vice-Chancellor of the Queen's University in Ireland, and the Presidents of the Queen's Colleges at Belfast, Cork, and Galway ; and the following statements were received :—]

UNIVERSITY OF ST. ANDREW'S.

St. Andrew's,
SIR, July 4th, 1870.

IN reference to your inquiry with regard to the sums from endowment or voted by Parliament applied to the advancement of science or to scientific instruction in the University of St. Andrew's, I beg to state that the only sums which can be considered as thus applied in this University are the salaries and parliamentary grants of the several scientific chairs, viz., Mathematics, Natural Philosophy, Natural History, Chemistry, and Medicine. These salaries and grants are stated in detail at page 38 of the Report of the Scottish Universities' Commission. I have asked the Secretary of the University to copy the details, and will enclose them to you. [*See below.*] And I desire to draw special attention to the great inadequacy of the endowments in the case of the Chairs of Chemistry and Natural History, the former particularly.

I am, &c.
JOHN TULLOCH, D.D.,
Senior Principal in the University.
J. Norman Lockyer, Esq.

EMOLUMENTS of the following CHAIRS in the UNIVERSITY of ST. ANDREW'S.

MATHEMATICS :	£	s.	d.	£	s.	d.
Salary under Act 20 George II. c. 32	—			71	0	0
Estimated share of surplus college revenues - -	—			129	18	0
Parliamentary vote –						
Present -	55	11	0			
New -	53	9	0			
				109	0	0
Estimated fees - -				200	0	0
				£509	18	0

NATURAL PHILOSOPHY :	£	s.	d.	£	s.	d.
Salary under Act 20 George II., c. 32 - - -	—			80	0	0
Estimated share of surplus college revenues - -	—			129	18	0
Parliamentary vote—						
Present - -	55	11	0			
New	91	9	0			
				150	0	0
Estimated fees - -				85	0	0
				£414	18	0

NATURAL HISTORY :	£	s.	d.	£	s.	d.
Salary under Act 20 George II., c. 32	—			60	0	0
Estimated share of surplus college revenues -	—			129	18	0
Parliamentary Vote—						
Present - -	55	11	0			
New	44	9	0			
				100	0	0
Estimated fees -				80	0	0
				£369	18	0

CHEMISTRY :	£	s.	d.
Income from Dr. Gray's Foundation, estimated by Commissioners at 125*l*., but does not exceed	90	0	0
New Parliamentary vote	125	0	0
Estimated fees	80	0	0
	£295	0	0

MEDICINE:	£ s. d.	£ s. d.
Salary under Act 20 George II., c. 32.	—	60 0 0
Estimated share of surplus college revenues	—	129 18 0
Parliamentary vote—		
Present	55 11 0	
New	44 9 0	
		100 0 0
Estimated fees		30 0 0
		£319 18 0

[Statement circulated in December 1871.]

It has long been felt by many to be very desirable that the educational resources of the University of St. Andrew's should be brought to bear more closely on the population of Dundee. Of late the need and the desire of that higher education, which universities alone adequately supply, have widely spread, and that desire is felt by many persons who have neither the means nor the leisure necessary for taking a regular University course.

Since such persons cannot go to the University, the question occurs whether the University cannot go to them. In England this feeling has found expression in some of the ablest of the Cambridge Fellows going to the large towns, especially in the northern counties, and lecturing to the mechanics and other working men, teaching them in night classes and examining them, and this with satisfactory results.

It has expressed itself still more decidedly in the foundation, by Durham University, of a regular College for the teaching of Physical Science in Newcastle-upon-Tyne. This college has just been opened, with a professorship of each of the following branches of science:—1. Pure and Applied Mathematics; 2. Chemistry; 3. Experimental Philosophy; 4. Geology, Mineralogy, and Biology. Of these professorships, Durham University has endowed two from its own resources. The other two are maintained by the annual interest of a sum of money which has been already subscribed by the inhabitants of Newcastle.

The funds at the command of St. Andrew's University would not enable it to make any such munificent contribution as Durham University has done. But it has occurred to some, who approve of such a scheme, that if St. Andrew's would contribute the services of (say) two of its professors, Dundee might perhaps furnish the means of in some measure remunerating their services, and also of founding one or two professorships in addition.

The branches which would seem at present to bear most directly on the peculiar needs of Dundee might perhaps be:—1. Chemistry; 2. Pure and Applied Mathematics; 3. Engineering; and 4. Technology, or the application of science to industrial and manufacturing purposes. Afterwards, and when the benefits of knowledge were more fully experienced and appreciated, an enlargement of the course might be made, and literary and other instruction included in it.

It would probably be advisable, at first, that most of the lectures should be delivered in the evening. Besides lectures, there would be regular practical teaching on the several subjects, accompanied by regular examinations.

The course of study would probably last for two years. At the end of each year there would be examinations, conducted mainly by Examiners from St. Andrew's or the other Universities; and at the close of the second year, those who succeeded in passing the final examination might receive the degree of Bachelor or Associate of Science from the University of St. Andrew's.

It is unnecessary, at present, to go into further details. The above outline has been sketched, not to lay down or fix what must be subject of future deliberation, but only to enable those to whom the scheme is submitted to form some idea of what is proposed.

Before anything can be done, it is desired to lay the proposal before some of the influential citizens of Dundee and its neighbourhood, with a view to ascertain how far such a proposal would meet their approval, and how far they believe that the inhabitants of Dundee would join in promoting it.

Those who have drawn up this scheme have done so entirely on their own responsibility. As it has never been formally submitted to the Senatus, or any of the Governing Bodies, of the University of St. Andrew's, they are not entitled to speak for these; but they entertain no doubt that, if the citizens of Dundee approve and practically promote the proposal, the University of St. Andrew's will give it a hearty support.

The United College, St. Andrew's,
February 24, 1872.

MY LORD DUKE,

I TRUST that I may be allowed to address to your Grace, as Chairman of "The Royal Commission on Scientific Instruction," a few remarks, in corroboration of the Memorial which the Senatus of this University has just forwarded to your honourable Commission.

As Principal of the United College, to which the Scientific Department belongs, and being deeply interested in the development of that department, I shall feel very grateful if your Commission will make any suggestions which will raise its efficiency or extend the range of its usefulness.

The subject, however, to which I would desire, at present, especially to invite your attention is, the proposal (referred to in our memorial) for the establishment of a College of Science in Dundee to be affiliated to this University. The call on St. Andrew's to attempt something in this direction seems most urgent.

On the one hand, there is this ancient University with its definite appliances (limited though they may be) for scientific instruction, its long established tradition of teaching and examination, and its power of granting degrees to ascertained merit.

On the other hand, there is the large and rapidly increasing population of Dundee, full of practical energy, full of wealth, but provided with the means of higher education so scantily that, perhaps, no population of equal size in these kingdoms is in this respect so poorly furnished.

The journey from St. Andrew's to Dundee now takes less than an hour by rail, but when the Tay bridge shall be completed the distance will be greatly diminished, and the communication between the two towns much increased.

It is obvious that if an educational alliance between St. Andrew's and Dundee could be cemented, the teaching powers of this University could be utilized to a much greater extent than they have ever yet been, and the efforts after scientific training, which Dundee unaided might make, would, under the guidance of the University, be saved from many mistakes, and directed at once into the best and most profitable channels.

In the printed proposal for an affiliated college at Dundee, reference has been made to what Durham University has lately done in this way for Newcastle.

I would further remind you of what your Grace and the other members of the Commission probably know—the earnest appeals in which popular institutes in the towns of Rochdale, Crewe, and Leeds have lately entreated the Senate of Cambridge University, to aid them in their endeavours after higher education. If no such earnest entreaties have yet been made by Dundee artisans to St. Andrew's University, it is not that the need in Dundee is less, but probably that, because it is in reality greater, it is not yet so keenly felt. All the more, therefore, because the field in Dundee is so large and so untilled, are the friends of scientific progress desirous to go and occupy it.

Overtures have been made to some of the leading citizens in Dundee in the hope that they will promote the scheme by pecuniary aid. In more than one quarter these are engaging the attention of intelligent men.

While these negotiations are still pending, nothing would more stimulate the scheme than a statement from your Commission that you regard it with approval, and think it worthy of encouragement. Such a recommendation, coming from such a quarter, would greatly strengthen the hands of all those who are already labouring to promote this end.

If the Commission see their way to further assist us, by making definite suggestions as to the best way of carrying out the object in view, or by recommending it to the Government as deserving of their support, this would still more ensure success.

It is not, however, for me to do more than to ask the Commission to take the whole proposal into their serious consideration, and, if they see fit, to favour us with their advice.

I will only add that if I can be of any service by giving more detailed information to your Commission, either as to the proposed affiliated college or as to any other aspect of the scientific resources of St. Andrew's, I shall feel it my duty to proceed as soon as possible to London, and appear before your Commission.

I have, &c.
J. C. SHAIRP,
Principal of the United College, in the
University of St. Andrew's.

To His Grace the Duke of Devonshire,
Chairman of the Royal Commission
on Scientific Instruction.

P.S.—As I expect to be in London on the 25th and 26th of March next, should the Commission desire me to appear before them, I shall be glad to do so at that time.

University of Glasgow.

Glasgow University,
August 9, 1870.

Sir,

In reply to your letters to the Principal of June 28th and August 6th, I enclose a statement of sums applied to the advancement of science in this University, and also a printed list of the students in actual attendance last winter session in the several classes of the University.

I am, &c.
Duncan H. Weir,
Clerk of Senate.

J. Norman Lockyer, Esq.

Statement of Sums applied to the Advancement of Science or to Scientific Instruction in the University of Glasgow which are derived from Endowments or from Parliamentary Grants.

I. *Endowments of Chairs.*

	From (1) *University Revenues.*	and (2) *Parliamentary Grant.*
(*a.*) Natural Philosophy	£267 4 5⅓	£21 0 0
Shuna Rents	20 0 0	—
Assistants and Class Expenses	100 0 0	100 0 0
	£387 4 5⅓	£121 0 0
(*b.*) Mathematics -	230 0 0	62 0 0
Shuna Rents	20 0 0	—
Assistant -	—	100 0 0
	£250 0 0	£162 0 0
(*c.*) Astronomy -	220 0 0	50 0 0
Assistant -	100 0 0	—
Wilson Astronomical Fund for Instruments, &c.	45 0 0	—
	£365 0 0	£50 0 0
(*d.*) Civil Engineering -	—	£275 0 0
(*e.*) Natural History	—	200 0 0
(*f.*) Chemistry	—	200 0 0
Assistants and Class Expenses	£70 0 0	200 0 0
(*g.*) Botany	—	200 0 0
Shuna Rents	20 0 0	—

II. *Bursaries, Prizes, &c.*

(*a.*) Watt prize of 10*l.* annually for an Essay on a Scientific subject.
(*b.*) Walker prizes in Civil Engineering and Mechanics; annual value 15*l.*
(*c.*) Cleland gold medal (10*l.* 10*s.*), awarded every second year to a student of Natural Philosophy.
(*d.*) Breadalbane Scholarships (two, each of 50*l.*, annual value,) in Mathematical and Natural Science.
(*e.*) Sir William Thomson Experimental Scholarships, three, each of 20*l.* annual value.
(*f.*) Neil Arnott prizes in Natural Philosophy, consisting of the free annual proceeds of Dr. N. Arnott's gift to the University of 1,000*l.*

University of Aberdeen.

University of Aberdeen,
August 6, 1870.

Sir,

I have now the honour to enclose, for the information of the Royal Commission, a statement of the amount of endowments and parliamentary grants applicable to scientific instruction, &c., in this University.

There are no funds for the maintenance of museums.

I have, &c.
P. C. Campbell,
Principal.

J. Norman Lockyer, Secretary,
Royal Commission on Scientific Instruction, &c.

Endowments and Grants for Scientific Instruction.

	Endowments.	Grants.	Total.
	£ s. d.	£ s. d.	£ s. d
Chair of Mathematics (average)	124 0 0	76 0 0	200 0 0
Assistant to ditto - -	62 0 0	38 0 0	100 0 0
Chair of Natural Philosophy (average).	186 0 0	114 0 0	300 0 0
Assistant to ditto - -	62 0 0	38 0 0	100 0 0
Chair of Natural History (average).	186 0 0	114 0 0	300 0 0
Chair of Anatomy -	—	150 0 0	150 0 0
Assistant to ditto -	—	100 0 0	100 0 0
Chair of Institutes of Medicine or Physiology.	—	200 0 0	200 0 0
Chair of Chemistry (average)	165 10 0	40 8 8	205 18 8
First assistant to ditto -	—	100 0 0	100 0 0
Second ditto - -	—	50 0 0	50 0 0
For class expenses -	—	100 0 0	100 0 0
Chair of Botany - -		300 0 0	300 0 0
Chair of Materia Medica -	—	150 0 0	150 0 0
Joint assistant to ditto, and Chair of Medical Jurisprudence.	—	50 0 0	50 0 0
For class expenses -	—	50 0 0	50 0 0
	785 10 0	1,670 8 8	2,455 18 8
Four Scholarships to Graduates for distinction in Mathematics, including Natural Philosophy, each 65*l.*	260 0 0	—	260 0 0
Neil Arnott Scholarship for most distinguished student in experimental branches of Natural Philosophy.	35 0 0	—	35 0 0
Simpson prize to first most distinguished graduate in examination for honours in Mathematics.	70 0 0		70 0 0
Boxill prize, to second ditto -	28 0 0		28 0 0
	£1,178 10 0	£1,670 8 8	£2,848 18 8

The above is a true statement of the amount of money, whether arising from endowments or from parliamentary grants, applicable to the purpose of scientific instruction in the University of Aberdeen.

P. C. Campbell, D.D.,
Principal.

University of Aberdeen,
6th August, 1870.

Communication from Professor Bain, Professor of Logic in the University of Aberdeen, on the Aid given to Scientific Instruction by that University.

To the Science Commissioners,

University of Aberdeen,
November 7, 1870.

Gentlemen,

Your circular letter, addressed to this University, respecting the endowments for science in the University, was explained by your Secretary to refer exclusively to the chairs of physical science, and the Senatus accordingly gave a statement of the emoluments of those chairs, together with certain prizes or scholarships in mathematics and natural philosophy.

Now, it humbly appears to me, as an individual member of the Senatus, that such a return, following the construction of the Secretary, understated in a very serious degree the funds for the encouragement of science belonging to this University, and obtained either from Parliament or from private donors.

The University has a sum of 4,000*l.* a year expended in nearly 240 bursaries or scholarships, tenable during the four years' curriculum in arts; the bursaries chiefly range from 10*l.* to 35*l.* a year, average about 17*l.* The cost of education is under 10*l.* a year. The effect of these bursaries is to educate and assist in maintaining upwards of 200 young men while pursuing a mixed curriculum of literature and the sciences, the literature consisting of the three languages, English, Latin, and Greek; the sciences being mathematics, natural philosophy, natural history, logic, and moral philosophy. Now I cannot see that the binding up of three languages with five sciences, in the curriculum, takes away from the benefactors of our University the credit of contributing largely to scientific education.

But farther. Nearly two thirds of the bursaries are given by public competition, the collective annual value of these being about 2,500*l.* Now, the subjects of competition were in former days confined to classical literature. For several years one fourth of the marks has been given for mathematics. By a scheme, coming into operation next year, chemistry and zoology are admitted into the list of subjects. The obvious tendency of such a competition is to make the bursaries instrumental in stimulating the study of science in the schools preparatory to the University.

Another contribution to science kept out of view by the accident of mixture is a sum of 260*l*. a year, bestowed in four scholarships of 65*l*. a year for four years, for proficiency in classics and mental philosophy. Assuming an equal share to the two departments, we may put down 130*l*. a year to logic, mental and moral science.

But as the Commissioners, in their enumeration of scientific chairs, excluded the chairs of logic and moral philosophy, they might probably not regard the last-named scholarships as in any respect scientific. I would with all deference represent this exclusion as unnecessary and unjustifiable. My grounds are briefly these:—

1. In every classification of the sciences, so far as my knowledge goes, logic and the moral sciences are included. Logic, in particular, has been viewed in all ages as touching the very vitals of science.

As a consequence and confirmation of the same unanimity, these sciences are included in the curriculum of every university in this country as well as in other countries. It cannot be maintained that they have ever been viewed as literature (it would be difficult to take that view of logic), or in any other connexion than with the sciences, such as mathematics or natural philosophy. Nor can this usage be set down as antiquated and about to disappear under superior enlightenment. The new degrees of science in the University of London, probably the most advanced step that has yet been made in our higher education, places logic and mental science in every respect on a footing of equality with the physical sciences.

2. Probably the Commissioners do not mean to take up the sciences in separation and detail, or to consider the special position of mathematics, chemistry, and biology severally in respect of public encouragement. To all appearance their purpose will be sufficiently answered by viewing science as a whole, or in mass, with occasional illustrative references to individual branches. In receiving evidence as to the endowments that Government and private benefactors have thought fit to bestow upon logic and the moral sciences they are not bound to dwell especially upon the needs of those sciences in particular. If they have any preferences they may indulge these without seeming to depart from the received curriculum of science as filled up by the wisdom of past generations.

3. It is not to be denied that the reference in the moral sciences to the self-conscious or subjective side of things makes a broad distinction between them and the physical sciences, in particular withdrawing them from the same precise experimental determination, and admitting easily the bias and distortion of the feelings. That this, however, is not a sufficient ground for striking them out of the catalogue of the sciences, may be maintained by the following arguments, leaving out considerations of greater subtlety:—

First. The great attention given to logic in the present day has led to its being regarded as a valuable auxiliary to the sciences altogether. There are many points of scientific method that have received their best elucidation from the logician who has made it a business to compare the sciences with one another in regard to their several peculiarities of method, and to consider method as a subject apart. Logic is, theoretically viewed, the most general of the sciences, in the very same sense that mathematics is more general than physics. As a practical branch of knowledge its province is all science; directly it assists in proof, indirectly in discovery.

Secondly. In psychology, as now cultivated, there is a very extensive groundwork of the strictly physical, on which the endeavour is to bring to bear all the recognised means of scientific investigation.

Thirdly. Even the subjective side may be and is handled by many in a strictly scientific spirit, and by methods borrowed from the sciences, with adaptations to the peculiar difficulties of the problem. These difficulties are undoubted, but the phenomena are definite and recurrent, as much so as the phenomena of life; and if nature offers regularly such phenomena for investigation, the name natural science, in the largest sense, cannot be withheld from the investigation of them, however difficult this may happen to be.

Fourthly. The imperfections still adhering to mental science, until quite lately belonged more or less to the physical sciences. These have all, in their turn, passed through a stage of loose determinations and the distortions of the feelings.

Fifthly. Many enlightened men have inculcated and exemplified the viewing of the sciences as a whole, if only for the perfecting of each. In this copartnery of mutual light-giving the claims of logic and mental science might be shown to be equal, if not superior, to the claims of any other department.

Lastly. The subjective sciences, with all their imperfections, are those that come most immediately into contact with the interests of humanity, on whose account alone importance attaches to any science whatsoever. It is according to the laws of human sensibility that every contribution to knowledge, and every practical application of knowledge, must work out the happiness of human beings. In fact, psychology prepares the way for a new start in the sciences; it leads on to political science, in the widest sense, including the department recognised by the British Association under the title "Economic Science."

I have, &c.
A. Bain,
Professor of Logic.

University of Edinburgh.

Detailed Statement as to Scientific Instruction and the means available for the Advancement of Science in the University of Edinburgh, with suggestions for the improvement of the same.—Drawn up by a Committee of Senatus for the information of the Royal Commission on Scientific Instruction and the Advancement of Science.

The Statement is arranged as follows:—

A. Enumeration of subjects.
B. Modes of teaching, and means of pursuing original investigation.
C. Funds annually applied to scientific instruction derived from endowments or parliamentary grants.
D. Funds annually allocated from the general University fund to scientific instruction.
E. Returns of the number of students attending classes in which science was taught during the session 1869-70.
F. University examinations in scientific subjects.
G. Suggestions as to aid required for scientific instruction, and for the advancement of science.
H. Full details as to mode of teaching already sketched under B. These are contained in the University Calendar.

A. Enumeration of Subjects.

The Departments of Science in the University, as referred to by the Royal Commission, may be classified under the following heads:—

1st. Natural Philosophy.
2nd. Applied Mathematics.
3rd. Physical Laboratory.
4th. Practical Astronomy.
5th. Agriculture.
6th. Music.
7th. Engineering (Civil and Mechanical).
8th. Mechanical Drawing.
9th. Surveying, Levelling, &c.
10th. Chemistry.
11th. Practical Chemistry.
12th. Chemical Laboratory.
13th. Physiology.
14th. Physiological Laboratory.
15th. Anatomy.
16th. Anatomical Demonstrations.
17th. Practical Anatomy.
18th. Natural History.
19th. Mineralogy.
20th. Geology.
21st. Botany.
22nd. Vegetable Histology.

Department of Science more strictly Medical:—

23rd. } Materia Medica.
24th. }
25th. Practice of Medicine, Medical Psychology, and Mental Diseases.
26th. Surgery.
27th. Practical Instruction in Bandaging and Surgical Appliances.
28th. Operative Surgery.
29th. Midwifery and Diseases of Women and Children.
30th. General Pathology and Morbid Anatomy.
31st. Practical Pathology and Morbid Anatomy.
32nd. Pathological Laboratory.
33rd. Clinical Medicine (with Wards in the Royal Infirmary).
34th. Clinical Surgery (with Wards in the Royal Infirmary).
35th. Medical Jurisprudence and Public Health. (Medical Police.)

B.—MODES OF TEACHING, AND MEANS OF PURSUING ORIGINAL INVESTIGATION.

1. *Natural Philosophy.*—A six months' course of five lectures per week, copiously illustrated by experiment, the subject being Physics generally, with elementary applications of Mathematics. This is properly a two-year course. Some branches are treated more fully than others one winter, and less fully the next. In addition, tutorial lectures by the class assistant, and fortnightly written examinations

2. *Applied Mathematics.*—Six months' course of three lectures per week (on Dynamics and the mathematical theories of Heat, Light, and Electricity), with occasional experimental illustrations and examinations.

3. *Physical Laboratory.*—Instruction and practice in the use of philosophical instruments, and in the conduct of experimental investigations and original researches. The Laboratory is open five hours daily during six months in winter, and three in summer.

4. *Practical Astronomy.* — The Professor of Practical Astronomy is also Astronomer Royal for Scotland, and has duties to perform in connexion with the Royal Observatory of Edinburgh, in which institution he can give practical instruction.

A course of lectures, illustrating the best methods of applying instrumental measurements to celestial phenomena. This course is not at present required for graduation in any of the Faculties. It was voluntarily commenced by the present holder of the Chair in the session 1850–51, and has in some years been carried to the extent of a six months' course; but latterly, on account of the increasing amount of his duties within the Royal Observatory, Edinburgh, on the one hand, and the always very small number of students offering at the College on the other hand, the Professor has limited himself to receiving (on the day announced in the University Calendar for opening the course) all matriculated applicants for Practical Astronomy, ascertaining their calibre and objects, and then advising or assisting such young men afterwards in their studies, at various periods through the session, according to circumstances, and gratuitously.

5. *Agriculture.*—A course of about 100 lectures, based mainly upon the "principles" of Agriculture, and showing as far as practical, in a class room (by diagrams and experiments), their important bearing upon the various operations and practice of the Farm. The applications of Chemistry, Botany, Geology, and Physics are discussed and explained in the course.

6. *Music.*—(1.) Free lectures on, for instance, some of the subjects enumerated in the Calendar (1), are given from time to time to about 100 (1870) matriculated students, whose names are on the roll at the Music class room as regular attendants at these lectures and at organ performances. At the latter, instructive remarks are made on the music selected, of which that by the great Masters occupies the greater portion of every programme. These performances and lectures are given on alternate weeks. (2.) There is also a working class (see 2 in the Calendar), members of which attend the above prelections and practical illustrations of the subject, to whom is imparted a course of weekly individual instruction, extending over five months. Students attending this class are separately instructed in Organ and Pianoforte playing, and also, as a *sine quâ non*, in Harmony or "Theory."

7. *Engineering.*—A six months' course of five lectures per week is given each winter session. The whole course occupies two years, and the subjects treated of are so arranged that it is a matter of indifference which session is taken first. About half the lectures in each session are devoted to Mechanical, and half to Civil Engineering. No attempt is made to cover the whole field of Engineering, but the student is shown how to apply the principles of Science to some of the chief branches of this profession. Weekly written exercises of some difficulty are set. The students are allowed a week for the necessary calculations, which are sent up in detail, and their exercises are returned to them, annotated by the Professor at some length. This addition to the purely professional mode of teaching is believed to be of great assistance both to the students and the Professor, but could clearly only be practised with a small class.

8. *Mechanical Drawing.*—A Drawing office is open for the winter six months, five days a week, from 10 a.m. to 2 p.m. The students attend in the intervals of other classes. Copies and models are provided, and for a small extra payment instruments are also found. No lectures are given, but the work is done under the supervision of the Professor of Engineering. Students are shown how to make figured sketches from machinery. Descriptive Geometry is not taught.

9. *Surveying, Levelling, and Setting-out.*—This is a practical class held hitherto at the beginning of the summer session. It requires the attendance of students at about 12 lectures, followed by about 12 whole days in the field. The use and adjustment of the level, theodolite, sextant, compass, chain, &c., are taught.

10. *Chemistry.*—A course of 100 lectures during the winter session, copiously illustrated by experiment, the subject being Chemistry, Inorganic and Organic. In addition, weekly tutorial lectures by the assistant, with frequent written exercises, and two written examinations during the session.

11. *Practical Chemistry.*—A three months' course of five hours' instruction per week, conducted by the Demonstrator, the subject being Elementary Qualitative Analysis.

12. *Chemical Laboratory.*—The Laboratory is open six hours daily during the winter and summer sessions. Practical instruction is given by the Professor and assistants in all branches of Chemistry, and facilities are afforded for original research.

13. *Systematic Physiology.*—This is taught in a five months' course of lectures, five in the week, illustrated by numerous coloured diagrams, and a great number of experiments, illustrative of the application of Physical Investigation to vital Phenomena.

14. *Physiological Laboratory.*—Practical Physiology is taught to classes not exceeding 20, in which each student is himself instructed. 1st. In the use of the microscope, and the examination of the animal tissues and fluids. 2ndly. In the employment of modern physical instruments in the investigation of Physiological Phenomena; this is Experimental Physiology. 3rdly. In the Chemical analysis of all the animal fluids and tissues; this is Chemical Physiology.

15. *Anatomy.*—A winter course of 100 lectures on the Anatomy of the human body, in which both its textural or general Anatomy, and its descriptive Anatomy are treated in a systematic manner. The lectures are illustrated by recent dissections, wet and dry preparations from the Anatomical Musuem, and a large collection of microscopic objects and diagrams. In addition, written examinations are held at intervals, and the junior members of the class receive special instruction in Osteology.

16. *Anatomical Demonstrations.*—A winter course of about 80 Demonstrations on the dissected human body, in which its structure is displayed and described topographically.

17. *Practical Anatomy* is pursued by the student for 10 months in the year, and the course is divided into a winter and summer session. In the summer session Anatomical Demonstrations are also given, and on one or two days each week specimens of Comparative Anatomy from the Anatomical Museum are described.

18. *Natural History.*—A six months' course of five lectures per week (except during the delivery of the Mineralogical lectures) in winter, and a three months' course of five lectures per week in summer. Winter and summer courses illustrated by diagrams and specimens from the Museum of Science and Art. Oral examinations at variable intervals during the winter and summer sessions. Excursions for dredging, &c., during the summer.

19. *Mineralogy.*—A course of about 20 lectures on Mineralogy during the winter, illustrated by specimens from the Museum of Science and Art.

20. *Geology.*—A Chair of Geology has just been founded by the munificence of Sir R. Murchison, aided by the Government.

21. *Botany.*—A three months' course of five lectures per week, delivered in the class-room at the Royal Botanic Garden. The lectures are fully illustrated by fresh specimens from the garden, dried specimens from the herbarium and class museum, models, and large drawings. A three months' course of practical demonstrations on plants cultivated in the open ground of the garden, as well as on plants in the conservatories and hot-houses. The demonstrations are given three days a week. Class examinations are held in a room in the University buildings once a week, and competitive examinations take place once a month by means of printed questions and fresh specimens. An excursion is made every Saturday during the courses in the neighbourhood of Edinburgh. These excursions extend to sixty or more miles from Edinburgh. At the conclusion of the course an excursion for a week is made [illegible] distant part of the country. These final excursions [illegible]times last

for a longer time, and have been extended to England, Ireland, and the continent of Europe.

22. *Vegetable Histology.*—Class meets twice a week under the superintendence of the Professor and his assistant; aid is also received from senior students.

23, 24. *Materia Medica*:—

1. Five months' lectures, five days a week, including, *a*, Pharmacy; *b*, Therapeutics; *c*, Diet; *d*, Regimen.
2. Class examinations, two in number.
3. Self-instruction by the students in a commodious museum of select specimens.
4. Laboratory for investigation.

25. *Practice of Medicine.*—A five months course of five lectures per week, the subjects varying in alternate years. In every year the principles of the practice of Physic are given under the head of constitutional and other diseases of tissues, as distinguished from diseases of organs. General diseases, as fevers, inflammations, epidemics, and endemics, are considered alternately with diseases of organs and of systems of organs. A distinct course of Medical Psychology, including mental diseases, is given during every summer session, which is illustrated by drawings and writings by the insane, and by cases in an asylum. Written exercises are requested, and examinations for class honours are held. Tutorial instruction is offered.

26. *Surgery.*—A five months' course of five lectures per week. The course consists of two divisions: (*a*) the general principles of surgery; (*b*.) the practice of surgery, or the application of the principles to the treatment of special diseases and injuries; also the performance of surgical operations. The lectures are illustrated by morbid preparations, dissections, sketches, casts, and diagrams. The application of surgical apparatus is shown, and the various operations of surgery are demonstrated on the dead subject before the class. Class examinations and competitive examinations periodically during the course.

27. *Practical Instruction in Bandaging, &c.*—This is conducted by the tutorial assistant. Each student performs the manipulations under his superintendence and direction. For this purpose the general class is divided into small sections. These classes meet thrice a week, from 9 to 10 a.m., and 2 to 3 p.m. Every pupil of the surgery class is expected to attend as no extra fee is charged.

28. *Operative Surgery.* This is a separate course given during summer. The students perform operations on the dead subject under the personal superintendence and direction of the Professor

29. *Midwifery and Diseases of Women and Children.*—A winter course of five lectures per week, illustrated by diagrams, drawings, models, and museum preparations. The diseases of women are taught clinically in a ward granted for the purpose by the managers of the Royal Infirmary. Oral examinations are held every Saturday. Two written examinations during the session.

30. *Systematic Course of Pathology and Morbid Anatomy.* Six months' course of five lectures per week, illustrated by morbid specimens, diagrams, &c. Demonstrations of morbid specimens and oral examinations are given once a week. Written examinations twice or thrice during the session.

31. *Practical Morbid Anatomy and Histology, and Practical Pathology.* Three months' summer course twice or thrice a week, morbid specimens being examined and demonstrated by the pupils; and pathological experiments conducted.

32. *Pathological Laboratory.* For practical instruction, and conducting researches and experiments. As yet not fully organised for want of funds and assistant.

33. *Clinical Medicine.*

1. By courses of lectures in the Royal Infirmary. In each course two lectures per week are given during the summer and winter sessions.
2. By instruction at the bed side.
3. By analyses, microscopic inquiries, and instruction in the use of aids to the physical diagnosis and treatment of diseases.

34. *Clinical Surgery.* A five months' course in the Royal Infirmary, consisting of two lectures per week during the winter session, and a three months' course, also of two lectures per week, during the summer session. The lectures are of a demonstrative character, and are supplemented by visits in the wards of the infirmary in the other days of the week.

35. *Medical Jurisprudence, &c.*—Lectures five days a week during the three summer months. Tutorial examinations and demonstrations in the laboratory by the class assistant once a week. Two competitive examinations by written questions.

MUSEUMS.

A large and valuable collection of instruments is attached to the Chair of Music.

Valuable Museums belonging to the University are attached to the Chairs of Natural Philosophy, Chemistry, Materia Medica, Physiology, Midwifery, and a Herbarium to the Chair of Botany.

The Anatomical Museum contains a large collection of preparations in illustration of Human Anatomy, both Normal and Pathological, and of Comparative Anatomy.

The Museum of Natural History, which at one time belonged to the University, was transferred in 1854 to the Government, and now forms a part of the collection in the Natural History Department of the Museum of Science and Art, the whole of which is available for the educational purposes of the University.

The Royal Botanic Garden is connected with the University, in so far as that the Professor of Botany is Regius Keeper. Ample facilities are afforded for studying the plants in the garden and in the Botanical Museum.

C. FUNDS ANNUALLY APPLIED TO SCIENTIFIC INSTRUCTION DERIVED FROM ENDOWMENTS OR PARLIAMENTARY GRANTS.

1, 2, 3. *Natural Philosophy.*

		£	s.	d.
Endowment of Chair.	Leith Harbour Annuity	22	4	4
	Parliamentary grant	180	0	0
Class Assistant—Parliamentary grant		100	0	0

4. *Practical Astronomy.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	300	0	0*

5. *Agriculture.*

		£	s.	d.
Endowment—Pulteney bequest, 50*l*. -		350	0	0
Granted in 1868.	Highland and Agricultural Society, 150*l*.			
	Parliamentary grant, 150*l*. -			

6. *Music.*

		£	s.	d.
Endowment of Chair from funds left for that purpose by General Reid.	Salary of Professor	420	0	0
	Class expenses:—			
	Assistants and instruments, &c.	300	0	0
	Annual concert -	300	0	0

7, 8, 9. *Engineering.*

		£	s.	d.
Endowment of Chair.	Parliamentary grant	200	0	0
	Sir David Baxter's Foundation	200	0	0
Class expenses—Sir David Baxter's Foundation		40	0	0

10, 11. *Chemistry.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	200	0	0

12. *Chemical Laboratory.*

From the Hope Prize Fund, a Biennial Travelling Scholarship, tenable for one year, value 100*l*	50*l*. per annum.

13, 14. *Physiology.*

	£	s.	d.
Endowment of Chair—Parliamentary grant	150	0	0

15, 16, 17. *Anatomy.*

Neither endowment nor Parliament grant.

18, 19. *Natural History and Mineralogy.*

		£	s.	d.
Endowment of Chair.	Parliamentary grant	160	0	0
	Thompsonian bequest	35	15	2

20. *Geology.*

		£	s.	d.
Endowment of Chair.	Sir Roderick Murchison's Foundation.	200	0	0
	Parliamentary grant -	200	0	0
Class expenses—Sir Roderick Murchison's Foundation.		40	0	0

---

* This sum is independent of other emoluments which the Professor of Practical Astronomy receives as Astronomer Royal for Scotland; the two offices being by his Commission conjoined.

21, 22. *Botany.*

		£	s.	d.
Endowment of Chair.	Parliamentary grant	160	0	0
	Leith Harbour Annuity	40	0	0

23, 24. *Materia Medica.*

	£	s.	d.
Endowment of Chair—Parliamentary grant	100	0	0

25. *Practice of Medicine.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	100	0	0

26, 27, 28. *Surgery.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	100	0	0

29. *Midwifery.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	100	0	0

30, 31, 32. *Pathology.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	100	0	0

33. *Clinical Medicine.*

No funds.

34. *Clinical Surgery.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	100	0	0

35. *Medical Jurisprudence.*

	£	s.	d.
Endowment of Chair—Parliamentary grant -	100	0	0

Total of Funds applied to Scientific Purposes under C.

	£	s.	d.
(*a.*) From Parliamentary grants - -	2,500	0	0
(*b.*) From other endowments	1,847	19	6

Note.—The Parliamentary grant of 100*l.* to the Chairs of Pathology, Midwifery, Surgery, Practice of Medicine, and Materia Medica, and a grant of 60*l.* to the Chair of Botany, were conferred, on the recommendation of the Scottish Universities' Commissioners, in lieu of the share of medical graduation fees, divided amongst the Professors of the Medical Faculty previous to the passing of the Scottish Universities Act. None of the Professors in the University of Edinburgh, who officiate as examiners for degrees, receive any remuneration for their time and trouble, though the work is now very onerous, and is annually increasing.

D. FUNDS ANNUALLY ALLOCATED FROM THE GENERAL UNIVERSITY FUND TO SCIENTIFIC INSTRUCTION.*

1, 2, 3. *Natural Philosophy.*

	£	s.	d.
By Ordinance of Commissioners –			
Class expenses	100	0	0
Annual vote of Senatus			
Mechanical Assistant	100	0	0

4. *Practical Astronomy.*

None.

5. *Agriculture.*

	£	s.	d.
Annual vote of Senatus			
For class expenses	5	0	0

6. *Music.*

None.

7, 8, 9. *Engineering.*

	£	s.	d.
Annual vote of Senatus for prizes	5	0	0

10, 11, 12. *Chemistry*

	£	s.	d.
By Ordinance of Commissioners –			
Salaries of Assistants	200	0	0
Class expenses -	100	0	0†

13, 14. *Physiology.*

	£	s.	d.
By annual vote of Senatus—			
Assistant -	100	0	0
Class expenses	50	0	0

15, 16, 17. *Anatomy.*

	£	s.	d.
By Ordinance of Commissioners—			
Class expenses and salary of Demonstrator of Anatomy	200	0	0*

18, 19. *Natural History and Mineralogy.*

	£	s.	d.
Annual vote of Senatus—			
Class Assistant - - -	30	0	0

20. *Geology.*

21, 22. *Botany.*

	£	s.	d.
Annual vote of Senatus for Assistant	25	0	0
Do. do. for Herbarium (including class drawings).	50	0	0

23, 24. *Materia Medica.*

	£	s.	d.
By Ordinance of Commissioners—			
Class expenses -	50	0	0
Class Assistant	25	0	0
Annual vote of Senatus—			
Class Assistant - - -	25	0	0

25. *Practice of Medicine.*

	£	s.	d.
Class Assistant, who works both in the University and the Professor's ward in the Infirmary	25	0	0

26, 27, 28. *Surgery—Bandaging and Surgical Appliances.*

	£	s.	d.
Annual vote of Senatus—			
Class Assistant - -	25	0	0

29. *Midwifery.*

None.

30, 31, 32. *Pathology.*

	£	s.	d.
Annual vote of Senatus—			
Class Assistant -	25	0	0

A special grant of 40*l.* towards providing apparatus was voted this year; and a sum for class expenses and apparatus will probably be granted annually, if the general University fund admits of the outlay.

33. *Clinical Medicine.*

No funds.

34. *Clinical Surgery.*

No funds.

35. *Medical Jurisprudence.*

	£	s.	d.
By Ordinance of Commissioners—			
Class expenses	35	0	0
Class Assistant	25	0	0
Annual vote of Senatus—			
Class Assistant	25	0	0

TOTAL OF FUNDS ALLOCATED FROM UNIVERSITY FUNDS FOR SCIENTIFIC PURPOSES UNDER D. (See first foot note, below.)

	£	s.	d.
(*a.*) By Ordinance of Commissioners	735	0	0
(*b.*) By annual vote of Senatus	490	0	0

E. RETURNS OF THE NUMBER OF STUDENTS ATTENDING CLASSES IN WHICH SCIENCE WAS TAUGHT DURING THE SESSION 1869–70.

NOTE.—*Attendance at the Classes of Botany, Natural History, and Chemistry, is required for Graduation in Medicine.*

1.	Natural Philosophy	185
2.	Applied Mathematics -	3
3.	Physical Laboratory -	20
4.	Practical Astronomy	1
5.	Agriculture	27
6.	Music } Division 1 (under "H") about	50
	Do. 2 do	8

---

* Conditional on the state of the General University Fund, which is principally made up from Matriculation and Graduation fees, and depends therefore on the number of students attending at the University, and on the number graduating. There are many other unavoidable charges on this fund, such as the maintenance of the College buildings, salaries of librarians, clerk, servitors, &c., &c., so the amount available for scientific purposes is very inadequate.

† The salaries of Assistants in the Chemical department amount to 431*l.*, and the excess of this over the 200*l.* allowed is paid by the Professor.

* This sum falls much below the annual amount which the Professor is called upon to expend, in order to carry out, in an efficient manner, instruction in Practical Anatomy.

7.	Engineering		26
8.	Mechanical Drawing		9
9.	Surveying and Levelling		12
10.	Chemistry		232
11.	Practical Chemistry		135
12.	Chemical Laboratory		15
13.	Systematic Physiology		127
14.	Practical Physiology		89
15.	Lectures on Anatomy		240
16.	Anatomical Demonstrations		159
17.	Practical Anatomy	Winter course	264
		Summer course	97
18. 19.	Natural History and Mineralogy		189
20.	Geology -		[No return.]
21.	Botanical Class -		283
22.	Vegetable Histology Class		38
23. 24.	Materia Medica		121
25.	Winter Session, Practice of Medicine		61
	Summer Session, Medical Psychology and Mental Diseases.		31
26.	Surgery -		110
27.	Bandaging Class		110
28.	Operative Surgery (Summer)		28
29.	Midwifery - -		110
30.	Systematic course of General Pathology and Morbid Anatomy -		100
31. 32.	Summer course of Practical Morbid Anatomy and Pathology -		18
33.	Clinical Medicine—Average for Summer and Winter Sessions, about		100
34.	Clinical Surgery	Winter Session	116
		Summer Session -	62
35.	Medical Jurisprudence -		69

F. UNIVERSITY EXAMINATIONS IN SCIENTIFIC SUBJECTS.

I. All candidates for the degree of M.A. are examined in Natural Philosophy and Applied Mathematics. Candidates for honours at the M.A. degree are allowed to select Natural Science as one of the departments. The subjects on which they are examined are Geology, Zoology, Chemistry, and Botany, and their attainments in these subjects are tested by written papers, and by practical and *viva voce* examination. Another department for honours is that of Mathematics, in which the candidates are examined in Pure and Applied Mathematics and Natural Philosophy.

II. All candidates for the degrees of Bachelor and Doctor of Medicine are required to pass an entrance examination, including, amongst other subjects, Mechanics and Natural Philosophy. They then undergo a preliminary scientific examination in Botany, Natural History, and Chemistry, and their attainments in these subjects are tested by written papers and by practical and *viva voce* examinations. Candidates who obtain more than 75 per cent. of the attainable marks, are placed in the honours list.

The attainments of candidates in Anatomy, Physiology, and the other more strictly medical departments of study are tested by written, *viva voce*, and practical examinations.

III. Candidates for the degrees of Bachelor and Doctor of Science, in the department of Physical and Natural Science, undergo a preliminary scientific examination in Mathematics, Natural Philosophy, Chemistry, Zoology, and Botany. This examination is called the First Bachelor of Science Examination. The candidate may then select one of the following groups for the second examination, on passing which, he attains the degree of Bachelor of Science.

(*a.*) The Mathematical Sciences { Higher Mathematics. Natural Philosophy.
(*b.*) The Physical Experimental Sciences - { Experimental Physics. Chemistry.
(*c.*) The Natural Sciences { Zoology, Botany. Physiology, Geology.

For the degree of Doctor of Science, the candidate must profess the science which he intends to be the special object of his future studies, and must further select a particular branch of it in which he believes himself to have attained a considerable knowledge.

IV. Candidates for the degrees of Bachelor and Doctor of Science in the Department of Engineering undergo a preliminary examination in Mathematics, Natural Philosophy and Chemistry. They may then proceed to the Second Bachelor of Science Examination in the following subjects:— Mathematics applied to Mechanics, Engineering and Mechanical Drawing. On passing this examination they receive the degree of Bachelor of Science in Engineering. The candidate for the degree of Doctor of Science in Engineering must profess one, and not more than one, of the subdivisions in each of two following groups of subjects :—

I.—Practical Engineering - {
(*a.*) The design of machinery, with complete drawings, specifications, and estimates.
(*b.*) The preparation of designs, Specifications, and estimates, for Civil Engineering work.

II.—Applied Science {
(*a.*) Applied Mathematics.
(*b.*) Chemistry.
(*c.*) Geology.
(*d.*) One branch of Natural Philosophy.
(*e.*) Telegraphy.

The examinations in group I. consist in requiring the actual execution of the specified work. The candidate is examined orally in connexion with the work submitted as his own.

The following is a list of the prizes, scholarships, &c., open to competition amongst students and graduates in Science and Medicine:

The Neil Arnott Prize of 50*l.*, for Experimental Physics, tenable for one year by a student of Medicine. A second prize is about to be founded by Dr. Arnott.

The Hope Chemistry Prize of 50*l.* per annum, for two years.

Baxter Physical Science Scholarship, 60*l.* a year, for two years.

Baxter Natural Science Scholarship, 60*l.* a year for two years.

Falconer Memorial Fellowship, 100*l.* a year, for two years.

The Ettles Prize, for the most distinguished medical graduate each year, 45*l.*

To encourage original research in the various departments of Medical Science, the University awards annually one or more gold medals to those graduates in Medicine who, in their Theses, have contributed new and important observations on the subject matter of the Thesis.

G. SUGGESTIONS AS TO AID REQUIRED FOR SCIENTIFIC INSTRUCTION AND FOR THE ADVANCEMENT OF SCIENCE.

1, 2, 3. *Natural Philosophy.*

Aid is urgently required in the forms of
(*a.*) Space for the collection of instruments.
(*b.*) Greatly increased accommodation for the Laboratory. The Professor has been unable to admit all who have applied, and even the limited number admitted [illegible] accommodated by want of room.
(*c.*) Increased grant for Mechanical Assistants.
(*d.*) Grant for purchase of instruments. The small grant designed for this purpose [illegible] the only available source, and [illegible] spent on them.

4. *Practical Astronomy.*

If this Chair is ever to be [illegible] numbers attending, there must be either a second Professor appointed [illegible], or an Assistant to the present Professor capable of devoting his whole time to it.

In either of such cases, besides the new salary thereupon necessary, it would be proper to supply the Chair with examples of all the most characteristic forms of modern astronomical instruments, at least of the smaller and more portable kinds, having special regard to all those varieties most frequently called for in the daily practical operations of Nautical Astronomy, Terrestrial Astronomy, and Cosmical Astronomy. Such apparatus is to be furnished gradually by means of a liberal annual grant, a part of which should be disposable, at the discretion of the Professor, for mechanical assistance, &c. &c.

Once [illegible] worthily attended to [illegible] held forth, and getting their real "*Practical* Astronomy," the Chair would then infallibly become a point of [illegible] honourable kind for the mature [illegible] as well as the juvenile *learners* in Astronomical Science in all parts of the country, on occasion of national expeditions for observation of Total Solar Eclipses, [illegible] of the Sun [illegible]. In [illegible] consummation so long, so loudly desired amongst many practical astronomers, the Chair would then be able to render important aid [illegible] to the Royal Observatory, Edinburgh.

5. *Agriculture.*

1. Advanced standard of teaching in the secondary schools.

2. A higher appreciation by proprietors and occupiers of land of the advantages of a special education.

3. The establishment of a Faculty or Department of Applied Science, in which Agriculture should be included, examinations held, and honours conferred.

4. The establishment of a Chair of Agricultural Chemistry in the University, or of a Laboratory attached to the Chair of Agriculture, in which the Chemistry of Soils, Crops, Manures, and Feeding Substances, could be investigated and practically taught.

6. *Music.*

Degrees of Bachelor and Doctor of Music should be instituted and conferred.

7, 8, 9. *Engineering.*

Aid is required in the forms of—

1. A class room.—No special class room is set apart for the class of Engineering, and thus much difficulty is found in arranging models, diagrams, and illustrative experiments.

2. Funds for the purchase of books, and especially of periodical literature. The Library funds of the University meet demands for new works published in Great Britain, but they are insufficient to subscribe for the very large number of Engineering and Scientific Periodicals published throughout the world. These periodicals are perhaps the most valuable part of the literature treating of Engineering. There is no library in Edinburgh containing any great number of them, and the Chair suffers seriously from the absence of those periodicals giving intelligence as to the yearly progress of Engineering.

3. An endowment for a lectureship of Mechanical Drawing. This class requires more constant supervision than can be given by the Professor of Engineering, and the efficiency of the class would be much increased by lectures on the simpler portions of Descriptive Geometry. Mechanical Drawing is not properly taught in any class in this city, and its acquisition is nevertheless of primary importance to a much larger class of the community than is embraced under the general head of Engineering.

4. The endowment of lectureships on special branches of Engineering, as, for example, Telegraphy and Mining. If such endowments were granted, the grant should be made for five years, to be continued only in case the average attendance of students had exceeded, say, 15 per annum. The attendance of students may be looked upon as a fair test of the success of a Chair.

5. Recognition by the State of degrees granted by the University. A degree of Engineering might free a candidate for a Government appointment from any mere pass examination, and might be allowed to count for a certain number of marks in competitive examinations. By this means training would be encouraged as compared with cramming.

10, 11, 12. *Chemistry.*

Aid is urgently required in the forms of—

(*a.*) Accommodation for the Practical Chemistry classes.
(*b.*) Accommodation for the Laboratory.
(*c.*) Increase of grant for Assistants' salaries.

13, 14. *Physiology.*

(*a.*) A room better lighted for teaching the use of the Microscope, the present room having only one window available. The lectures, consequently, have to be repeated two or three times daily to small classes of students.

(*b.*) Increase of annual grant for purchase of diagrams, repair of instruments, extending the collection, and the purchase and feeding of animals.

(*c.*) A properly constructed court yard, with cages, in which animals may be kept for purposes of observation and experiment.

(*d.*) Increase of salary for Laboratory Assistant.

15, 16, 17. *Anatomy.*

Aid is required in the forms of—

(*a.*) Increased space for the dissecting room, lecture theatre, and apartments for special research.
(*b.*) Addition to the space and grant for the anatomical museum.
(*c.*) Increase of grant towards class expenses and Assistants' salaries.

18, 19. *Natural History and Mineralogy.*

20. *Geology.*

21, 22. *Botany.*

(*a.*) Additional grant for assistance in class museums and herbarium.

(*b.*) Allowance for microscopes and other apparatus, models, and drawings required both for teaching and original investigation in Structural and Physiological Botany.

(*c.*) Allowance for class prizes.

(*d.*) Allowance for a consulting library in connexion with the herbarium.

23, 24. *Materia Medica.*

Modern improvements point to practical instruction in Pharmacy as also desirable, but the accommodation in the Professor's apartments is wholly insufficient for that purpose.

25. *Practice of Medicine.*

Increase of salary for Class Assistant.

The department of Medical Psychology and Mental Diseases requires aid—

1. For the scientific investigation of the physical conditions which correlate all states of consciousness.

2. Access to an hospital for the insane, or clinical wards for their practical and pathological study.

3. A suitable retiring room, with proper conveniences for the placing and examination of objects appropriate for class instruction. The Professor is wholly destitute of any accommodation of this kind.

4. Allowance for class expenses.

26, 27, 28. *Surgery.*

(*a.*) Increase of salary for Class Assistant.

(*b.*) Suitable accommodation for teaching the classes for Practical Bandaging and the course of Operative Surgery.

29. *Midwifery.*

(*a.*) An addition to the salary of the Class Assistant.

(*b.*) Addition to the space and grant for the Museum.

(*c.*) Wards for clinical instruction in Midwifery and Diseases of Children should be attached to the Chair.

30, 31, 32. *Pathology.*

Accommodation for laboratory.

Grant for Assistants.

Grant for apparatus and instruments.

Endowment to some extent of the Chair, so that the Professor might devote more time to investigations connected with his department.

The Chair of Pathology, as including Morbid Anatomy, ought to be officially connected with the Pathological Department in the Royal Infirmary. This is a very important matter, both for teaching and for scientific progress.

33. *Clinical Medicine.*

(*a.*) Room for the instruments required for clinical teaching and research.

(*b.*) A suitable laboratory for microscopic and chemical investigation.

(*c.*) Grants for Assistants.

(*d.*) Grant for purchase of instruments and for class expenses.

The only source of aid is the funds of the Royal Infirmary of Edinburgh, which are not collected for this purpose, but for the relief and cure of the sick.

34. *Clinical Surgery.*

Aid is not required in this department of instruction.

35. *Medical Jurisprudence.*

The allowance for the Class Assistant is too small.

H. Full Details as to Mode of Teaching already sketched under B above.

These are to be found in the University Calendar for 1870, *pp.* 57 *to* 164, *inclusive.*

From the foregoing statement of the requirements of each department of Science, it will be seen that the University stands in urgent need of great additional accommodation, more especially in connexion with the practical teaching and advancement of Science. The space at its disposal for museums, laboratories, and other apartments for practical work, is far below what modern experience has shown to be necessary for efficiently carrying on a thoroughly organised practical system of instruction and original research.

The funds at the disposal of the University are altogether insufficient, not merely to provide such accommodation, but even in many cases to obtain the necessary materials, and to give an adequate remuneration to the Class Assistants.

If an additional grant were obtained, the University would be enabled to develope its resources as a teaching body, and to give much more efficient aid than at present in the Advancement of Science.

A. GRANT,
January, 1871. Principal and Vice-Chancellor.

THE ROYAL OBSERVATORY, EDINBURGH.

Royal Observatory, Edinburgh,
Feb. 8th, 1871.

SIR,

I BEG to announce that I have prepared, and am about to forward to you printed, a statement to lay before the Royal Commission for Scientific Instruction and the Advancement of Science, with reference to this Royal Observatory, as an institution essentially for the Advancement of Science.

Personally, I have some connexion with the University of Edinburgh, a Scientific Instruction Corporation; but the Royal Observatory, Edinburgh, has no such connexion. Its chief friends, therefore, in this city have thought that the duty devolved on me, its Director, of representing its claims to Government attention before your Royal Commission, the terms of constitution of which seem to them to promise more opening for the true Advancement of Science than anything which has been inaugurated by Her Majesty's Government during the last half century.

I remain, &c.
C. PIAZZI SMYTH,
Astronomer Royal for Scotland, and
Professor of Practical Astronomy
in the University of Edinburgh

J. Norman Lockyer, Esq.,
Secretary to the Royal Commission
On Scientific Instruction and the
Advancement of Science

Royal Observatory, Edinburgh,
Feb. 9th, 1871.

DEAR SIR,

HEREWITH, agreeably with my letter of yesterday, I have the pleasure of sending you a copy of my Report for the Royal Commission on Scientific Instruction and the Advancement of Science, and I forward also a roll of copies of the same, so that there may be an example for each Commissioner, and I remain (pro Royal Observatory, Edinburgh),

Yours, &c.
J. Norman Lockyer, Esq., C. PIAZZI SMYTH
Secretary to the Royal Commission
On Scientific Instruction and the
Advancement of Science.

[The following is the statement referred to in Professor Piazzi Smyth's foregoing letters.]

STATEMENT prepared for the Royal Commission on Scientific Instruction and the Advancement of Science, by C. Piazzi Smyth, the present Director of the Observatory; February 1871.

1. This Royal Observatory is but a small establishment, peculiarly circumscribed too, and, as it were, locked in on several sides, yet enjoying some distinctive features of foundation, neighbourhood, and opportunities which have already enabled it to perform a considerable amount of useful work, either not at all, or very little, attended to elsewhere; and it might, under more favourable circumstances for development than it has yet enjoyed, be enabled to accomplish much more of the same character in the service for the advancement of science.

2. It is a Government Observatory, under the charge immediately of the Secretary of State for Home Affairs; whose Office, in conjunction with the Treasury, is pledged, for now more than a quarter of a century, to the members of the late Astronomical Institution of Edinburgh (the original founders of the Observatory with their own private and voluntary subscriptions), to keep it up in all future time as "a proper and independent Royal Observatory." Its personal establishment consists of a Director, entitled by Government, "Astronomer Royal for Scotland," and two Assistant Observers. While its instrumental equipment notably includes a first class Transit-Instrument and a 6-foot Mural Circle, to which a large Equatorial of special construction and peculiar adaptation is now about to be added by H.M. Government.

3. The situation is on the summit of the Calton Hill in the midst of the city of Edinburgh, with an admirable foundation of the firmest trap-rock for Meridian piers; but inordinately exposed to violent winds, superabundant smoke, and injurious chemical vapours; with no opportunity either for adding to, or altering in any manner, the actual building, the masonry of which, while it is exceedingly substantial, architectural even to successful classicism, and ornamental to the city, is yet on a very contracted scale. The building, moreover, is inconveniently isolated, too little protected, and with the Astronomer's house a long way off, at the foot of the hill, and without possibility of being brought any nearer.

4. The path of work and usefulness chosen for this Observatory by Thomas Henderson, the first appointed Astronomer-Royal for Scotland, in 1834, had sage reference to all these ruling data of circumstance; and consisted, mainly, in Meridian observations for place, chiefly of small stars. The system so begun has, with due regard to the precedence and deservedly high claims of the Royal Observatory, Greenwich, been continued up to the present time, and has been found exceedingly appropriate: 12 quarto volumes of the Observations thus obtained have been printed, a 13th is now in progress at the press; and the system, it is to be hoped, will never be given up so long as the nation cultivates exact Astronomy; the most precious foundations of which noblest of the sciences, in dynamics of the starry heavens, may be confidently expected to be thus furnished, illustrated, and strengthened as generation after generation of observers passes away.

5. Coincidently, however, both with the above work, and some other phases of usefulness to the community which may be gathered from the Report on the employments of last year in Enclosure II. [see further on], the present Director has aimed at introducing certain extra-Meridian Observations of a more special and experimental character as part of his roll of duties. For if these additional researches are of so nice or discriminating a character that they require to be followed up, not on the smoky Calton Hill, nor, indeed, in any portion of our cold and cloudy high-latitude part of the Northern Hemisphere, but by occasional expeditions to more Southern, favourable, and, sometimes, even distant regions of the Earth's surface,—he considers that his forced non-residence at his Observatory,—a drawback to him when at home, unknown amongst all the other public Observatories of the country, besides the damp and murkiness of its situation even at the best, points him out pre-eminently as the one of all others of the British professional astronomers to be charged with the duty of cultivating "peripatetic," as well as "stationary," astronomy.

6. The Edinburgh Astronomer has, accordingly, travelled

in 1851, to Norway to observe a Total Solar Eclipse.
" 1856, to the Peak of Teneriffe, to prosecute a long-continued series of Astronomical experiments above the cloud level.
" 1859, to Russia, for the furtherance of a certain unsolved problem in Nautical Astronomy: and
" 1864, to Egypt, to apply astronomical and other measures to the Great Pyramid, situated at the centre of the land surface of the entire globe, and forming the most ancient monument of intellectual and religious man still existing.

And he would have gone forth much oftener, had he been furnished with the requisite funds; but on none of the above occasions was the Edinburgh Astronomer aided with any Government grant, except in 1856, when he received 500*l.* from the Admiralty: a sum, however, so insufficient for the widely ramifying character of that very unique expedition, that he was left in starving debt then also, as in 1859 and 1864, to the extent of more than a year's salary.

7. Hence the one earnest request which the Astronomer-Royal of Scotland has now to prefer to the Royal Commisioners,

That they would be pleased to recommend to H.M. Government that both he and his Observatory should in future be better endowed, so as to enable him to undertake these expeditions of Peripatetic Astronomy not only more frequently but with better instruments than he has hitherto had the command of.

8. As a subsidiary portion of the same request, he would beg of the Commission to procure the dissociation of this

---

* Almost all the instruments used on the Teneriffe Expedition were borrowed for the occasion, and not a few instances have occurred since then, when a further [illegible] would have afforded to the observations [illegible], if the identical instruments employed had remained in the possession of the Edinburgh Royal Observatory, where they could have been more [illegible] [illegible], if afterwards found necessary, for [illegible] particulars, necessary corrections, or repetition [illegible] under [illegible] circumstances.

modern and active Astronomer-Royalship of Scotland from a much older appointment to which it has very needlessly been tacked on by name, *i.e.*, the Regius Professorship of Practical Astronomy in the University of Edinburgh; an undeveloped and impossible College Chair which, for many reasons set forth several months ago in writing to the Principal of the University for presentation, on his part, to the Royal Commission, can never expect to be really useful to the College, though it is always exceedingly obstructive and restrictive to the Observatory.

9. Freed, therefore, then from the inopportune trammels of this mere ghost of a Chair in the University, and enabled by Government to obtain the appropriate instruments and to pay for their transport on scientific journeys, the Astronomer-Royal for Scotland firmly believes that he and his official successors would, under Divine Providence, be enabled, in this manner, to do more good work both for the advantage of Astronomy and the credit of the Royal Observatory of Edinburgh, than by spending twice the sum on the present miserable arrangements and conflicting interests of those two most opposite and ill-agreeing institutions; viz., on the one hand, the huge University, pre-eminently for the teaching of science as a branch of general education, and for "coaching" young men through the difficulties of competitive examinations in order to their gaining salaried or money-making situations in the ordinary affairs of life; and, on the other hand, the small Observatory, for advancing Astronomical Science, and for giving some instruction in it also, but to those, by preference, who are prosecuting it for its own pure and exalted sake alone.

ENCLOSURE I.

FINANCIAL STATEMENT of the ROYAL OBSERVATORY, EDINBURGH, for 1871.

The whole of these sums are derived from Parliamentary Grants, and there are no others.

	£	s.	d.
A.—PERSONAL SALARIES.			
(1.) The Astronomer Royal for Scotland, under the pay-office name of "Professor of Practical Astronomy in the University of Edinburgh," but, in intention, as above, per annum -	300	0	0
(1') The Astronomer Royal for Scotland, both by name and in intention -	100	0	0
(This is a late addition, accorded by Government, on account of the total insufficiency of the former sum, after an experience of 30 years, for the duties of the situation.)			
(1") A residence (nearly free) for the same officer at 15, Royal Terrace, Edinburgh. This is a new house, recently built by Government, containing several public rooms for the Royal Observatory, besides the Astronomer's private apartments; and is so very much more suitable to Astronomical life and work than the Astronomer's former house, that it must be regarded as a most admirable move on the part of H.M. Government, and the chief boon they have conferred on the Observatory of the late Astronomical Institution of Edinburgh since they first came into use or possession of that building 37 years ago.			
(2.) The first Assistant Observer, per annum	200	0	0
(2.') A free, but too contracted, residence in the tower called "the Old Observatory," within the grounds of the present Royal Observatory.			
(3.) The second Assistant Observer, per annum -	100	0	0
(3.') Additional Meteorological computation pay, per annum - -	10	0	0
And increasing by 10*l.* per annum to 50*l.*			
(3.") No residence yet accorded, but held to be very desirable.			
B.—OBSERVATORY ALLOWANCES.			
(1.) For lighting, cleaning, warming, servants' wages, repair of instruments, postage, stationery, and all contingent expenses, except the maintenance of the buildings, per annum - -	200	0	0
(This sum, though more than it used to be, is yet found to be sadly insufficient; for it allows of no purchase of new apparatus, no important improvements or salutary changes such as experience and use suggest from time to time, no special investigations of physical circumstances and difficulties which often crop up during long series of astronomical observations, no purchase of new books, not even the complete binding of the old and presented ones, and limits the foreign correspondence.)			
(2.) For Meteorological computations for the Registrar-General of Births, Deaths, &c., in Scotland; also printing, stationery, &c., for the same, per annum -	100	0	0
(3.) The maintenance of the Royal Observatory buildings is assigned by Government to the Office of H.M. Works, and is attended to by the local Superintendent thereof, R. Matheson, Esq., in a first-rate and most satisfactory manner.			
(4.) The printing of the Astronomical Observations is conducted, by Order of Government, under the care and superintendence of H.M. Stationery Office, and is highly approved.			
(5.) There is a Board of Visitors to the Royal Observatory, Edinburgh, consisting of 10 Members, 5 official and 5 unofficial, but all of them decided on, and appointed by H.M. Government; the unofficial Members being so chosen as to represent both the late Astronomical Institution of the City, which originated and actually built the present Observatory, and several other Associations, and Classes of Citizens who have in later years been more or less donors to, and benefactors of, the Observatory, in its various efforts for advancing Astronomy. This Board receives a printed Report from the Astronomer once a year, and communicates thereon with H.M. Government, as represented by the Principal Secretary of State for Home Affairs. The services of the Board are entirely Honorary, except in the receipt of a copy of the publications of the Observatory. But it is considered that a salary for the Member who acts as Secretary to the Board would be highly expedient, in view of the more onerous and positive character of the duties which fall to his share, and require to be both promptly and punctually performed.			

ENCLOSURE II.

A YEAR'S WORK, of the ROYAL OBSERVATORY EDINBURGH, as described in a Report recently prepared by request for the Anniversary Meeting of the Royal Astronomical Society of London; February 1871.

1. During the past year, the daily Times services, by Electric Ball, Gun-fire, and Controlled Clocks, have been continued as usual. Also the more laborious, and equally obligatory, work of computing the bi-diurnal observations collected from each of 55 Town and Country stations of the Scottish Meteorological Society, and sending the chief results, in certified forms, to be printed by the Registrar General of Births, Deaths, &c., in Scotland at the end of every month and quarter; and they have been printed accordingly.

2. The long kept up weekly observations of the carefully planned and very accurate series of the Edinburgh Observatory rock-thermometers, have recently been reduced, on one uniform plan, from their commencement in 1837, down to the end of 1869; and in that shape have been communicated to the Royal Society of London. A discussion of certain supra-annual cycles of temperature in the earth's surface crust, thus arrived at, accompanied the MS. figures; together with a forecast founded upon them, of the temperature characteristics to be, of the present

season; the date of communication of that forecast having been the beginning of last March.

3. Excepting only a few instances, the usual Meridian Observations of stars for place, with the Transit Instrument and Mural Circle, have been discontinued for a time; partly, because there has been only one assistant in the Observatory during a large portion of the year; and partly in order to allow of the computation of past observations in Right Ascension and N. Polar distance being more speedily overtaken.

4. A Report of 34 pages with several plates (intended to appear also in the 13th volume of the Edinburgh Astronomical Observations now commencing at the press), addressed to the Government Board of Visitors, has been printed by the Astronomer during the past summer, and generally circulated. It contains, amongst other Observatory topics, an inquiry into the fluctuations of the position of the Transit Instrument on the Calton Hill, during the last 29 years, and traces them up, both astronomically and experimentally, at last, it is believed, to their true source, viz., the untoward physical nature, touching thermotic effects, of the particular kind of stone in which the said piers are constructed; and an inquiry is, therefore, now much desired to be commenced into the degrees of suitability of different materials for the most exacting of the astronomical requirements of a first-class Meridian Observatory.

5. To accomplish all the above out-turn of work, under the difficult circumstances, too, which occurred, much extra labour was demanded from each person in the Observatory; and the Astronomer speaks with the highest praise of Mr Alexander Wallace, the first, and, for a large part of the year, his only Assistant. As to himself, the Edinburgh Astronomer did not, and could not, leave his post on the hill for a single day throughout the whole of the past year. It has come upon him, therefore, rather severely at the last, especially, too, after conducting a correspondence through several months with the University of Edinburgh bearing most distinctly upon the date of appointment of the Royal Scientific Commission of last May in London, and its connexion, in its one half of Scientific Instruction or "teaching," with the ancient University, and in its other half of the Advancement of Science, "by other methods than teaching," with the Meridian Observatory on the Calton Hill, that the said University has [illegible] to countenance a popular [illegible] to the effect of the Astronomer being a sinecurist, [illegible] an idler, and the only person belonging to the [illegible] who does nothing, or next to nothing, for his pay. [illegible] whatever particle of pay or emolument he gets, [illegible] directly [illegible], and [illegible] not much altogether [illegible] apart from that of his [illegible] both at home and in [illegible] in the College, but from the Government; and can be shown to have been given, in [illegible], for the work in the Royal Observatory, which [illegible] the Astronomer does labour at, already set [illegible] both by night and by day, and even then cannot fully [illegible]. Yet the College, taking sharp advantage of a [illegible] nominal form under which part of the money, for convenience sake, is paid by Government to its Astronomer, [illegible] the sum prominently in their own University [illegible] as belonging to the College, or as the endowment, [illegible] and [illegible], of a "Chair" therein; while they are [illegible], careful to keep out of view, in the same place, all [illegible] of the work done for that money within the Royal Observatory. And did the College, *i.e.* the University, [illegible] all-compelling power on public opinion [illegible], to be allowed to go on thus peremptorily [illegible] from the Astronomer in the Royal Observatory [illegible] Calton Hill, the full service of a regular teacher [illegible] for the College purposes within its own Academic [illegible] and establish that as the only grade by which he [illegible] salary, who, it may well be asked, is [illegible] to the Astronomer's already covenanted and [illegible] exhaustive duties at the self-same time within the Royal Observatory? For, [illegible], one man cannot be [illegible] very different places at once; and though the addition of one more teacher to the large number already in the University would be but a drop in the great [illegible] very material economic [illegible] advancing [illegible], as that of the Royal Observatory, [illegible] the forcible abstraction of [illegible], and [illegible] removal to other employment, could not [illegible] otherwise than a [illegible] drawback on its [illegible] for work and [illegible] and required Observatorial line.

C. P. S.

Royal Observatory, Edinburgh,
February 13th, 1871.

SIR,

I BEG to acknowledge yours of the 10th instant, stating, firstly, that you have laid my Report before the Royal Commissioners, and, secondly, that they will shortly ask me to appear before them.

For the first, I thank you; and for the second also, in the evident intention which it shows on the part of the Commissioners to go into their important duties thoroughly, but as to the carrying out of this No. 2 in practice, pray allow me to say that the prospect rather troubles me; because, on one side, my contracted income does not allow of my visiting London, and, on the other, unless the questions to be asked me *vivâ voce* are put as clearly and distinctly as I have made our transit clock here strike out its seconds' ticks most audibly, I may have considerable difficulty in fully hearing them.

Hence, I do trust that the Royal Commissioners may find it possible to send me what questions they see fit to ask, by letter; and they shall find both in the promptness and directness of the replies, that my respect for their work and position is not less than that of any of the parties who may attend personally.

I remain, &c.
C. PIAZZI SMYTH,
Astronomer Royal for Scotland.

J. Norman Lockyer, Esq.,
Secretary to the Royal Commission
On Scientific Instruction and the
Advancement of Science.

UNIVERSITY OF DUBLIN.

IN laying before the Commissioners a statement of the present condition of our Scientific School, we propose to adopt the same division of the subject with that indicated in Her Majesty's Commission itself, stating:—

1. The provision made in the University of Dublin for Scientific Instruction.
2. The provision made for the Advancement of Science.

I.

Scientific Instruction is given either as a part of general education or in connexion with the special professional Schools of Medicine and Engineering.

(1.) General Scientific Instruction is given partly by the Tutors, partly by the Professors. By an arrangement among the former, this duty is always assigned to those who have shown that they possess a special aptitude for the task, and the same rule is adopted in dividing among the lecturers the different branches of Science. Provision is also made for the different capacities of the Students by the institution of two classes of Lectures, called respectively "Ordinary Lectures," and "Honour Lectures;" the first being intended for ordinary Students, the second for the higher class of Students, who aspire to Collegiate Honours and Prizes. In the Junior Classes this provision for the different capacities of Students has been carried even further, by the appointment of separate Lecturers for the higher and lower Classes of Candidates for Scientific Honours.

The Lectures of the Professors, so far as they regard general education, have been to a certain extent arranged on a similar principle. Wherever it has been possible to provide a second Lecturer on the subject treated by the Professor, the attention of this latter has been confined to the higher class of Students. This is the case with the Professors of Pure and Applied Mathematics, who only lecture Candidates for Fellowship, Moderatorship, and Scholarship.

The Lectures of the Professors differ from those of Tutors, in being, generally speaking, less Catechetical, and more of the nature of Prelections.

Students are encouraged to attend these several Lectures by the rule which permits, under certain restrictions, attendance upon a Term of Lectures to be substituted for the passing of an examination.

In defining the course appointed to be read by Undergraduates, the principle has been adopted of fixing the subjects of Lectures and Examinations strictly during the first two years, and allowing to Students a certain power of selection during the last two. By this arrangement every Student must become acquainted with Mathematics, Mechanics, and Astronomy, while some other subjects are to a certain extent optional, a selection being, on these subjects, allowed to the Student. Thus, Junior Sophisters are permitted to take up, at their discretion, Classics, or Experimental Physics; and Senior Sophisters may select any two of the three following Courses:—

Mathematical Physics.
Experimental Physics.
Classics.

It will thus be seen that Experimental Science forms part of the Arts Course in Trinity College. The same is true to a certain extent of Natural Science. Some years ago a Tripos was founded for these subjects combined. This has been lately subdivided into two; the one, which is called "Moderatorship in Experimental Science," including the Sciences of Light, Heat, Sound, Electricity, Magnetism, Chemistry, and Mineralogy; the other, which is called "Moderatorship in Natural Science," including Geology, Zoology, Botany, with Physiological and Comparative Anatomy. It has been resolved to complete the connexion of Natural Science with the Arts Course, by placing it on the same footing with Experimental Physics as an alternative subject.

Instruction is given in Experimental Physics, both by Lectures and Demonstrations.

The Professor of Experimental Philosophy lectures on Heat, Electricity and Magnetism, Sound and Light. Junior and Senior Sophisters obtain credit for terms, by attending these Lectures along with others. Students in the Professional Schools of Medicine and Engineering are also required to attend.

In connexion with the instruction given in the Experimental Sciences, there is a Museum of Natural Philosophy, which contains a Collection of various Philosophical Instruments, adapted to illustrate the different departments of Natural Philosophy. A Museum of Geology and Mineralogy, which contains Typical Collections of Minerals and Fossils. And a Laboratory of Practical Chemistry, divided into compartments, each furnished with a complete set of the ordinary reagents, and capable of accommodating nearly sixty Students working simultaneously. The Students have been so anxious to avail themselves of the advantages thus afforded, that the Laboratory is, during working hours, quite full.

The Natural Science teaching in Trinity College, Dublin, is conducted by the Professors of Geology, Mineralogy, Botany, and Zoology; the arrangements for instruction are the following:

The Professor of Geology delivers three Courses of Lectures annually, on Physical Geology, Petrology, and Palæontology. He has also under his care the Palæontological Museum, containing a good Collection of Typical Fossils, arranged Zoologically.

The Professor of Mineralogy delivers one Course of Lectures, and has supervision of the Mineralogical Collection.

The Professor of Botany gives one Course of Demonstrations, and one Course of Lectures annually, on Structural and Physiological Botany, and is Director of the College Botanic Gardens. He also is Keeper of the University Herbarium.

The Professor of Zoology delivers annually two Courses of Lectures on Animal Morphology and Classification, and has under his care the Zoological and Ethnological Museum, containing an Excellent Typical Collection of Specimens.

It is in contemplation to increase the amount of instruction in Natural Science afforded to the Students, and the Natural Science Professors have submitted to the Board a scheme of a two years' Course of Lectures on this subject.

Beside the arrangements above mentioned, there is a Course of Lectures on Comparative Anatomy delivered annually by the Professor of Anatomy in the Summer Session, which, though primarily intended for Medical Students, is opened freely to all Arts Students of the College.

A School was established about 30 years ago, with the view of enabling Students in Arts to obtain the Theoretical and Practical instruction necessary for the Profession of Civil Engineering.

The Instruction, which is given partly by Lectures, and partly in the Laboratory and the Field, extends over three years, at the end of which Students may present themselves for the final Examination. Those who have passed this Examination are qualified to obtain a Degree or a License in Engineering from the University.

The Subjects of the Course are distributed as follows:—

First Year.—Mathematics, Theoretical Mechanics, Chemistry, and Mineralogy.

Second Year.—Practical Mechanics, Experimental Physics, Drawing and Surveying.

Third Year.—Geology and Practical Engineering.

A Museum of Engineering Models, illustrative of the principal Practical Operations of Civil Engineering, is attached to this School. It contains a series of Models, illustrating the Progress of Invention in the Steam Engine, Models of Locomotive, and the Cornish Pumping Engine; a large Collection of Timber Bridges, and Lattice Structures.

Besides the Practical Medical Teaching afforded by the Lectures of the Professors of Medicine, Surgery, Materia Medica, Medical Jurisprudence, and Midwifery, the following system of Scientific Training is afforded to Students:—

In Anatomy and Physiology, instruction is given by the Professor of Anatomy, who, during the Session, attends daily, assisted by the University Anatomist, and by a Staff of Six Demonstrators, giving Practical Instruction to the Students. A large, new, and airy Dissecting Room was built six years ago, fitted up with all the modern appliances for Anatomical Teaching. The Professor of Institutes of Medicine gives an Annual Course of Lectures on that branch of Physiology.

There is also a large Anatomical Museum, open daily to Medical Students, under the charge of a Curator.

Instruction is given to Medical Students in Physical Science, by the Professors of Experimental Physics and Chemistry, and an extensive Chemical Laboratory is available for Practical Teaching.

II.

The provisions made for the Advancement of Science may be classed under three heads, namely:—

1. Foundation or organisation of Professorships in different departments of Science.

2. Foundation or improvement of Observatories and Laboratories.

1. Within the last 40 years, six new Scientific Professorships have been founded in the University of Dublin, namely:—

Professorship of Civil Engineering.
Professorship of Applied Chemistry.
Professorship of Geology.
Professorship of Mineralogy
Professorship of Zoology.
Professorship of Surgery.

Within the same period, five already existing Professorships have been organised, in such a way as greatly to increase their efficiency, namely:—

The Professorship of Pure Mathematics.
The Professorship of Applied Mathematics.
The Professorship of Experimental Philosophy.
The Professorship of Astronomy.
The University Anatomist.

2. Within the same period a new Observatory has been erected for the special purpose of Observations in Meteorology and Terrestrial Magnetism. In this Observatory an elaborate series of observations at stated hours has been carried on during a lengthened period; and the results of these observations for the first 11 years have been recently published in two quarto volumes.

The Astronomical Observatory has lately received large additions and improvements. The large object glass presented to Trinity College by Sir James South has been mounted as an Equatorial in an Observatory specially constructed to receive it, and a new Meridian Circle, with all the modern improvements, and carrying a telescope of six inches aperture and eight feet focal length, has been ordered from Messrs. Pistor and Martin of Berlin, and is expected to be completed in the course of the next month.

It is proposed to erect a Physical Laboratory on an extended scale. This when complete will be of the highest utility both for education and for purposes of original research.

The Queen's University in Ireland.

Queen's College, Belfast.

Queen's College, Belfast,
July 18th, 1870.

Sir,

I have the honour of furnishing and now sending the return required in your letter of 27th June. Some delay was occasioned by my absence from home for a few weeks at the sea-side.

If any other information should be required, I shall be happy to supply it.

I send by this post (to your address) a copy of our College Calendar, in which, at page 173, will be found a list of the salaries of professors, and also of private endowments, at pages 164 to 167.

I have, &c.,
P. Shuldham Henry, President.

The Secretary, Royal Commission on
Scientific Instruction, &c

RETURN of SUMS derived from PARLIAMENTARY GRANTS and applied to Scientific Instruction in QUEEN'S COLLEGE, BELFAST.

				Yearly.		
	£	s.	d.	£	s.	d.
Senior Scholarships, yearly, 4 at 40*l*. each, viz., Mathematics, Natural Philosophy, Chemistry, and Natural History	—			160	0	0
Junior Scholarships, (Arts) Science, 5 in each of the three under graduate years, at 24*l*. each: 15 at 24*l*.	—			360	0	0
Class Prizes at the end of the Session, about	—			35	0	0
Books for Libraries—Mathematics	15	0	0			
Natural Phiosophy	20	0	0			
Chemistry	15	0	0			
Natural History	15	0	0			
General Scientific Works	40	0	0			
				105	0	0
For Class Illustration and Practical Teaching—Natural Philosophy	35	0	0			
Chemistry	30	0	0			
Museum	70	0	0			
				135	0	0
				795	0	0
In addition to the above there are—						
5 *Engineering Scholarships*, 20*l*. each	100	0	0			
8 *Medical* ditto 25*l*. each	200	0	0			
Class Prizes for Engineering and Medical Students at close of the Session, about	25	0	0			
				325	0	0
Books for Library—Engineering	15	0	0			
Medical	40	0	0			
Instruments, &c., for Engineering	25	0	0			
Medical Museums	80	0	0			
				160	0	0
				485	0	0

	£	s.	d.
Total for pure Science	795	0	0
,, Engineering and Medicine	485	0	0

Queen's College, Belfast,
15th July 1870.

Queen's College, Cork.

Queen's University, Dublin Castle,
June 29th, 1870.

SIR,

IN reference to your circular letter of the 27th inst., I beg to reply to the same as regards the Queen's College, Cork.

By *science*, as regarded by your Commission, I presume is meant the "*natural* and *physical* sciences," "*mathematics* and *chemistry*" included.

For the instruction in those subjects there exist in Queen's College, Cork, professors whose salaries are paid from the endowment charged on the Consolidated Fund as follows, at present:—

Mathematics	£320
Natural philosophy	320
Chemistry	292
Zoology and botany	292
Mineralogy and geology	292

Besides which those professors receive the fees paid by students for attendance on their lectures.

The materials—as apparatus, specimens, diagrams, books for library, &c.,—for the illustration of lectures and support of the laboratories and museum, and a small botanic garden, are provided out of a vote of 1,000*l*. taken annually in the House of Commons for the Queen's College, Cork, and of which about 150*l*. is usually allocated to the departments of the mathematical, physical, and chemical sciences, and about 100*l*. to the departments of the natural sciences.

All permanent fitments for the laboratories and museum are provided by the Board of Works.

A head and assistant gardener, a library porter, a laboratory assistant and a porter, a museum porter, and a porter in charge of the physical cabinet, are paid from the endowment fund. Their collective wages may be taken at 220*l*. per year; but the gardeners have also charge of the College grounds, and the library porter is more properly chargeable to the library and professional departments of the College, than to the purely scientific subjects.

I remain, &c.,
ROBERT KANE,
President of Queen's College, Cork.

J. Norman Lockyer, Esq.
Secretary, &c.

Queen's College, Galway.

Queen's College, Galway,
July 15th, 1870.

SIR,

IN reply to your letter of the 27th ult., I am directed by the President to say, for the information of the Commissioners on Scientific Instruction and the Advancement of Science, that the income of this College is derived from a permanent endowment of 7,000*l*. per annum charged on the Consolidated Fund under the provisions of the 8th and 9th Victoria, c. 66, s. 12; an annual parliamentary grant at present amounting to 1,000*l*.; and the fees payable by students in the several departments of the College. This latter source of income is very small, as each student is only required to pay to the College, for college purposes, 5*s*. in each year of his attendance, except the first, when the fee is 10*s*.

The allocation of the endowment fund is fixed by the College Charter, of which I enclose a copy. If you refer to chapter xvii. p. 28, you will find the fullest information on this head. I may also refer you to chapter ix. p. 21, for details as to the scholarships alluded to in the former chapter.

As to the distribution of the parliamentary grant, I enclose a document showing the manner in which it was allocated last year. This is the usual mode of distribution, but deviations from it are sometimes permitted by his Excellency the Lord Lieutenant of Ireland, on the recommendation of the President.

You will observe that many of the departments of this College are not "scientific," but as I am not quite certain how far any of them may not come within the scope of the enquiry indicated in your Commission, I have thought it better to furnish you with the above details in the fullest manner. Should any further particulars or explanations be required, I shall be ready to supply you with them.

I have, &c.,
WM. LUPTON,
Registrar.

The Secretary,
Royal Commission on Scientific Instruction
and the Advancement of Science, Westminster.

Allocation of Annual Grant for the year ending 31st March, 1870.

	£	s.	d.	£	s.	d.
History and English Literature Department	85	0	0			
Ancient Classical Department	20	0	0			
Modern Languages ,,	20	0	0			
General Library ,,	15	0	0			
				140	0	0
Mathematical ,,	30	0	0			
Physical ,,	30	0	0			
Chemical ,,	30	0	0			
				90	0	0
Natural History ,,	15	0	0			
Geology ,,	15	0	0			
				90	0	0
Engineering ,,				10	0	0
Medical ,,				90	0	0
Metaphysical ,,	16	13	4			
Legal ,,	16	13	4			
Economical ,,	16	13	4			
				50	0	0
Office Expenses				250	0	0
Heating and Lighting				150	0	0
Botanical Garden and Ground				100	0	0
				£1,000	0	0

(See Question **13,169**, Vol. II. p. 308.)

THE ENGINEERING SCHOOL, QUEEN'S COLLEGE, GALWAY.

The course of instruction pursued at Queen's College, Galway, in the Department of Engineering, extends over a period of three years, and is intended to impart to its students a sound knowledge of the scientific subjects which form the basis of their profession, together with as much practical work as can conveniently be given in a College.

This College does not profess (as a few of the home and continental institutions do) to give its students all the knowledge requisite for the practice of civil engineering. Such an undertaking is simply an utter impossibility. As well might one expect in a law or medical student directly proceeding from any of the legal or medical schools a competency such as would entitle him to undertake a heavy chancery suit or a serious surgical operation. But it gives to its pupils what can never be attained in an office, and what is absolutely necessary for a well-educated engineer, namely, a thorough knowledge of the scientific principles of his profession, as well as an acquaintance with other practical sciences directly bearing on the pursuits of his life.

Students, therefore, who have duly completed the College curriculum, and have received the University diploma, are directed to enter the office of an engineer engaged in the construction of works, where he will have an opportunity of seeing the principles which he has been studying carried out in practice, and where he will acquire a knowledge of details which can only be obtained in such a situation. After serving in this capacity for a period of say two years, he will then possess such a knowledge of his profession as will fairly entitle him to enter on the active duties of life.

The following programme of the courses and subjects of each year, together with the University and College Examinations passed by the students, will give a good idea of the system of instruction imparted by this institution to pupils in engineering :—

PROGRAMME of EXAMINATION and COURSES in the DEPARTMENT OF ENGINEERING, Queen's College, Galway.

"The Matriculation Examination" candidates are examined in the following subjects :—

Arithmetic.—Including Vulgar and Decimal Fractions, the Rule of Three, Simple Interest, and the Extraction of the Square Root.

Algebra.—Including Fractions, Proportion, and the solution of Simple Equations.

Geometry.—Euclid, Books I., II., III., VI. With definitions of Book V.

History.—Outlines of Ancient History.

Geography.—Outlines of Ancient and Modern Geography.

English.—English Grammar and Composition.

In the first year, a course of lectures, extending over three terms, is given in each of the following subjects :—

French.
Chemistry.
Mathematics (Pure).
The principles of Geometrical Drawing.
The practice of Drawing in the School.

The course of lectures in Geometrical Drawing embraces the following subjects : —

Construction of Geometrical Figures and Curves, such as occur in Machinery and Engineering.
Formation of scales.
Descriptive Geometry.
Projections of the Intersections of Surfaces.
The principles of Isometric Drawing.
The principles of Perspective, and the Theory of Shadows.

In the Drawing School, the Students are occupied during the first year in plotting surveys from field books, drawing some elementary, but useful, pieces of machinery and carpentry. They also make isometric and perspective drawings from Orthographic Projections.

The subjects of the second year, which also embraces three terms, are as follows :—

Experimental Physics.
Mathematical Physics.
Mathematics (Pure).
Civil Engineering.
Office Work.

Civil Engineering of this year includes the following subjects :—

The construction, manipulation, and adjustments of all the engineering instruments.

The theory of levelling and surveying, with and without the aid of a theodolite.

The mode of laying out railway curves.

The method adopted for measuring and laying out earthwork, traversing, and mine surveying, taking out masonry and quantities from drawings, and the principles of trigonometrical surveying. In this year the students make a practical section in the field, a large survey with the chain; they also make a traverse survey, lay out a railway curve, and measure some inaccessible heights by means of the theodolite; in the office work of this year the pupils are chiefly occupied in plotting their sections, and taking out the earthwork for a line of road, in plotting their surveys and taking out the acreage. In drawing stone and wooden bridges, and other engineering structures.

The course for the third year, which also occupies three terms, embraces the following subjects :—

Natural Philosophy, applied Mathematical Physics.
Geology and Mineralogy.
Engineering.
Office Work.

The Engineering of the third year consists of the following subjects :

The natural properties and strength of materials.

The pressure of earth on retaining walls. The methods of calculating stresses in iron and wooden structures, such as roofs, bridges, &c.; hydraulics, supply of water to towns, drainage and sewerage, foundations, locomotive and pumping engines, roads and railroads. The Grecian orders, and the Gothic styles.

In the office work of this year the students are occupied in drawing iron, wooden, and stone bridges, canal locks, and other engineering structures.

In the College, the students, irrespective of the scholarship examinations, pass a sessional examination at the end of each year. In the University, two examinations, one at the end of the second year, and the other at the end of the third, called the Diploma Examination.

The College Session begins in the middle of October, and ends the second week in June.

The College is furnished with a good library and well-supplied museums, all of which are used by the students.

The course of Geology and Mineralogy extends over three terms, and is divided into the following subjects :—

1st Term.—Physical Geology and Physical Geography.
2nd Term.—Mineralogy and Nature of Rocks.
3rd Term.—Palæontology.

In addition to attendance on the above courses, the students are required to make sections and geological excursions, accompanied by the Professor.

In the Museum, the fossils, of which there is a very large collection, are arranged stratigraphically, and the minerals chemically, according to Dana's System in his *Manual of Mineralogy*.

There is also a complete set of models of all the crystals, a great supply of rocks, both local and foreign, and a large collection of Marbles, and all the great ores of iron.

The school is also well supplied with geological maps and diagrams, suitable for lecturing purposes.

The chemical course extends over the three terms of the first year.

The first two terms, and a portion of the third, are occupied with inorganic chemistry, and the remainder of the third is devoted to organic chemistry.

In the second and third years the students are allowed, at a very moderate fee, to practise in the laboratory, which is well supplied with all the requisite apparatus and chemicals.

In the School of Natural Philosophy, the students, during the second year, attend a course of mixed mathematics, and also a course in experimental physics extending over three terms.

In the third year they attend a more advanced course of mixed mathematics, and also a course of practical mechanics, specially applied to mechanism and engineering.

The school is well supplied with all the apparatus requisite for experiments in the natural sciences. There is also a collection of models to illustrate the machinery used for engineering purposes, and a fine lathe at which the students can work.

EDWARD BERWICK,
President

Edward Townsend, M.A.,
Professor of Engineering,
July 9, 1872.

APPENDIX VI. (See Questions **13,371, 13,372,** Vol. II., p. 325.)

CATHOLIC UNIVERSITY OF IRELAND.

EXHIBITIONS AND PRIZES TO BE COMPETED FOR DURING THE YEAR 1872.

N.B.—The Rector and Council of the University reserve to themselves the right of withdrawing from competition any of the following Exhibitions, or of altering the date of the Examination, giving notice of the withdrawal on or before the 1st July 1872, or of the change in the date on or before the 1st of October.

SPECIAL EXHIBITIONS FOR COLLEGES AND SCHOOLS.

During the year 1872, Exhibitions of 20*l.*, tenable for one year, will be offered to the competition of Students in approved Colleges or Schools, subject to the following

Regulations.

1. One Exhibition will be offered in each College or School, in which four *bonâ fide* competitors offer themselves. It will be open to the competition of all Students in each College or School, subject to the approval of the Head of the College or School.

2. The Exhibition will be offered for Classical or for Mathematical proficiency, according as the Rector, upon consultation with the Head of the College or School, shall determine.

3. The Examinations for the Exhibition will be held in the College or School at the period of the annual visit of the University Examiner, and will be conducted under his personal supervision. They will be carried on by means of printed questions, and written answers, which, at the conclusion of the Examination, will be sealed by the Examiner, and conveyed by him to the University, to be there adjudicated upon.

4. The subjects of Examination for the Classical Exhibitions will be, Latin and Greek Grammar, and Latin Composition; and the following books:—

Homer, *Iliad*, i., ii., iii., and any Greek play or prose writer to be especially approved by the Rector.
Virgil, *Æneid*, i., iii.
Cicero, *in Catilinam*, i., ii., iii., iv., or any other Latin prose writer to be especially approved of by the Rector.

Proficiency in Greek and Latin Grammar, and in Latin Composition, is an indispensable condition of success; and special consideration will be given to Latin Verse and Greek Composition.

The Examination for the Mathematical Exhibitions will include Arithmetic, the first two books of Euclid, and the matter which is usually contained in Algebraical Treatises, within the limits of Simple Equations. Questions will also be set in the following subjects, which are optional, but for which special marks will be given, viz.:

Euclid, Books III., IV., and VI. (Definitions of V.); Algebra, including Quadratic Equations; Logarithms; and Trigonometry (solution of Plane Triangles).

5. No Exhibition will be awarded unless for distinguished answering.

6. The successful competitors may proceed to reside in the University in October 1872, or they may remain in their respective Colleges for a period not exceeding one year, with the permission of the Rector. But they cannot enjoy the Exhibition except while they attend Lectures in the University, and comply with the Rules and Regulations applicable to their Course.

7. The Exhibition will be forfeited by any misconduct which the Rector in Council shall, in his discretion, judge deserving of such punishment.

8. The Rector, upon consultation with the Heads of the several Colleges and Schools, will determine the Colleges and Schools to which Classical or Mathematical Exhibitions respectively will be offered. At the same time he will determine the special Greek and Latin book which will form, in each case, the subject of examination.

9. The Heads of the several Colleges are requested to transmit to the Rector the names of the Candidates who propose offering themselves, on or before the 15th of June.

UNDERGRADUATE EXHIBITIONS TO BE COMPETED FOR IN OCTOBER, 1872.

General Regulations.

1. The following Exhibitions, tenable for one year, will be offered for competition by the University on Monday, 14th October 1872, and following days, as mentioned below.

2. The Examinations will be held in the University buildings, Stephen's Green, and will commence each day at 10 a.m.

3. Candidates are required to send in writing their names and commendatory letters from their University or Collegiate Superior to the Secretary of the University, on or before October 1st, 1872.

4. No Exhibition will be awarded unless for distinguished answering; and, in the case of all the Classical Exhibitions, proficiency in Greek and Latin Grammar, and in Latin Composition, is an indispensable condition of success.

5. Every Exhibition is tenable for one year; successful candidates are required to attend Lectures in the Faculty of Philosophy and Letters, or of Science, according to their standing, and can hold the Exhibitions so long only as they observe the Regulations of the University, and show distinguished proficiency in the matter of the Exhibitions.

6. No one, however, can hold two Exhibitions in the same matter—*e.g.*, two Classical or two Mathematical Exhibitions. No Exhibition can be held by a person who has held the same Exhibition twice before.

7. The Exhibitions are open to all who present satisfactory testimonials of conduct, and former successful competitors may again compete for them, subject to the above-mentioned conditions, and to the special regulations in each case. But the Candidates cannot be above 26 years of age, or of more than four years standing in any University.

8. The Exhibitions are divided into Junior and Senior Exhibitions. Students eligible for the former may compete for the latter; but not *vice versa*. Candidates for the Senior Exhibitions must have passed the Scholarship Examination in the University, if by their standing they are required to do so.

N.B.—Students may present themselves for the Scholarship Examination in any Term *after* the third from their matriculation. And by a recent regulation of the Council, they are required to pass it [illegible] before the Eighth Term.

JUNIOR EXHIBITIONS.

Special Regulations.

1. No Student above 22 years of age, or who has resided for more than two Terms in any University, will be allowed to compete for the Junior Exhibitions. The successful candidates must attend the Lectures of the First or Second Year.

2. The subjects of the Examination for the Classical Exhibitions will be

Latin and Greek Grammar;
Latin Composition;
The Elements of Ancient Geography;
The Elements of Roman History (from the beginning of the Republic to the Battle of Actium), and of Greek History (from the Legislation of Solon to the death of Philip),
And the books, &c., appointed for each class of Exhibitions respectively.
Special consideration will be given to Latin verses and Greek prose composition.

I.—Entrance or First Year's Exhibitions.

Open to Persons entering the University, and to Students who shall not have resided in the University for more than two Terms previous to October 1872.

Classical.—One Exhibition of 20*l.*, two of 15*l.*, and four of 10*l.* each, for proficiency in the Classical and Literary matter of the Entrance Examination.

Candidates for these Exhibitions will be examined in the subjects mentioned above (No. 2), and in the following books:

Homer, *Iliad*, i., ii., iii.
Cicero, *Catil.*, i., ii., iii., iv.
,, *pro Archia Poeta.*

N.B.—Candidates for the Entrance Classical Exhibitions are reminded that the award will depend chiefly upon their satisfactory answering in Greek and Latin Grammar, and Latin Prose Composition; and proficiency in these subjects is an indispensable condition of success.

Mathematical.—One Exhibition of 20*l.*, two of 15*l.*, and four of 10*l.* each, for proficiency in the following subjects, viz.:

Necessary Subjects.—Arithmetic; Euclid, I., II.; Algebra (to simple equations inclusive).

Additional Subjects with Special Marks:—Euclid III., IV., and VI. books (defs. of V.); Algebra (including Quadratic Equations and Logarithms); Plane Trigonometry (solution of plane triangles).

II.—*Second Year's Exhibitions.*

Open to all Students of the University (affiliated or others) who shall have passed the Annual Examination of the First Year, and shall not have resided more than Five Terms in the University.

Classsical.—One Exhibition of 20*l.*, two of 15*l.*, and two of 10*l.*

Candidates for these Exhibitions will be examined in the subjects mentioned above (No. 2), in Greek Composition, and in the following books:—

Sophocles, *Œdipus Rex*, *Œdipus Coloneus*, and *Antigone*.
Herodotus, Book viii., ix.
Cic. *in Verrem*, vi.
Terence, *Andria* and *Heautontimorumenos*.

Mathematical.—One Exhibition of 20*l.*, two of 15*l.*, and two of 10*l.*, for proficiency in the following subjects:—

Necessary Subjects.—The additional subjects of the first year.

Additional Subjects with Special Marks:—Elements of Solid Geometry; Spherical Trigonometry; Coördinate Geometry; Theory of Equations.

SENIOR EXHIBITIONS.

III.—*Third Year's Exhibitions.*

Open to Students of the University who shall not have resided in the University more than Eight Terms, and shall have passed the Scholarship Examination.

Classical.—One Exhibition of 30*l.*, one of 20*l.*, and one of 10*l.*

Candidates for these Exhibitions will be examined in the subjects mentioned above (No. 2), in Greek Composition, and in the following books:—

Plato's *Republic*, i., ii., iii., iv.
Euripides, Ion and Bacchae.
Lucretius, i., ii.
Cic, *Tusc. Disp.*, i., ii., iii., iv.

Special marks will be given for Greek and Latin verse.

Mathematical.—One Exhibition of 30*l.*, one of 20*l.*, and one of 10*l.*, for proficiency in the Mathematical Honour Course of the Second Year, viz.:—Differential and Integral Calculus. Candidates are liable to be examined in the previous parts of the Mathematical Course.

Cloyne Exhibitions.

Founded by the Bishop and Clergy of the Diocese of Cloyne.

Limerick Exhibitions.

Founded by the Laity of the County and City of Limerick.

Conolly Exhibitions.

Founded by the late John Conolly, Esq.

Cloyne Exhibition, in Logic, 20*l.*—For proficiency in Logic, formal and critical.

Cloyne Exhibition in Mental Science, 20*l.*—For proficiency in Mental Philosophy (including Ontology and Psychology) and Natural Theology.

Limerick Classical Exhibition, 40*l.*, and
Two Cloyne Classical Exhibitions, each 30*l.*

Candidates for these Exhibitions will be examined in:—

Greek Grammar and Composition, both prose and verse;
Latin Grammar and Composition, both prose and verse;
Ancient History;
Ancient Geography;

And in the following books:—

Plat., *Rep.*, iii., iv., v.
Æschylus, *Agamemnon*.
Thucydides, i., ii., iii.
Cæsar *de Bello Civili*, i., ii.
Cic., *Tusc. Disp.*, i. ii., iii., iv.

And in two or more other Greek and Latin authors, at the option of the Examiners.

Cloyne Exhibition in Irish History, Literature, &c., 20*l.*:—

Elements of the Irish Language: Materials of Irish Literature, Irish History, from the Mission of St. Patrick to the English Invasion.

Two Limerick Modern Literature Exhibitions, &c., 20*l.* each, viz.:—

I. English History from the Conquest, 1066, to Edw. III. 1327, and English Language and Literature.
II. Any one of the three following subjects, at the choice of the candidate:
    (*a.*) French History, from the accession of Hughes Capet (987), to the death of St. Louis (1270); and the French Language and Literature.
    (*b.*) Italian History, from the Sicilian Vespers (1282) to the Invasion of Italy by Charles VIII. (1494); and the Italian Language and Literature.
    (*c.*) German History, from the Restoration of the Western Empire by Charlemagne (800), to the election of Frederic Barbarossa (1152); and the German Language and Literature.

Exhibitions in the Faculty of Science.

Three Limerick Mathematical Exibitions, one of 40*l.*, one of 30*l.*, and one of 20*l.*

Candidates for these Exhibitions will be examined in the full University Course of Higher Mathematics and Mathematical Physics.

Two Conolly Mathematical Exhibitions, 20*l.* each, viz.:—

I. Mathematics.—The full University Course of pure Mathematics, as far as Integral Calculus, inclusive.
II. Natural Philosophy.

Two Conolly Exhibitions in Experimental Science, 20*l.* each, viz.:—

I. Heat, Light, Electricity, and Magnetism; Elements of Geology, Physical Geography and Climatology, and Astronomy.
II. Chemistry.

SUBJECTS FOR THE ANNUAL EXAMINATIONS, SESSION 1871–2.

Pass Courses.

Religion.—History of Old and New Testaments, General Councils, and heresies condemned by them.

First Year.

I. Greek and Latin Classics:—

Herodotus, viii., ix.
Terence, *Andria*, *Adelphi*, *Phormio*, and *Heautontimorumenos*.
Plautus, *Mostellaria*, and *Aulularia*.

II. Mathematics:—

Arithmetic, Euclid, i., ii., iii., iv., v.
Algebra to Quadratic Equations, inclusive.
Solution of Plane Triangles.

III. Modern Language and History.

e.g., Irish, English, French, &c.

Second Year.

I. Greek and Latin Classics:—

Plato, *Gorgias*.
Sophocles, *Trachiniæ*.
Euripides, *Ion*.
Lucretius, i., ii., iii., v., vi.

II. Mathematics:—

Plane Trigonometry and Elements of Experimental Physics.

III. Logic, or Mental Philosophy.

Third Year.

I. Greek and Latin Classics:—
  Plato, *Repub.*, iii., iv., v.
  Soph., *Antig.*
  (or) Cicero, *Tusc.* i. ii. iii. iv.
  Persius.

II. Natural Philosophy (Experimental).
III. Mental Philosophy.

Additional for Honours

First Year.

I. Greek and Latin Classics:—
  Sophocles, *Œdipus Rex, Œdipus Coloneus,* and *Antigone.*
  Cicero, *in Verrem*, vi.
  Quintilian, xi., xii.

II. Mathematics, Plane Trigonometry, Coordinate Geometry, Conic Sections, and Theory of Equations.
III. Logic.

Second Year.

I. Greek and Latin Classics:
  Plato's *Republic*, i., ii.
  Æschylus, *Agamemnon.*
  Plautus, *Mostellaria.*
  Cicero, *de Divinatione.*

II. Mathematics:—
  Coördinate Geometry, Conic Sections; Euclid, Book xi., xii. Spherical Trigonometry, Differential Calculus.

III. Natural Philosophy and Chemistry.
IV. Mental Philosophy.

Third and Fourth Years.

I. Greek and Latin Classics:—
  Aristotle's *Ethics*, i., ii., iii., iv.
  Pindar's *Olympiacs* and *Pythiacs.*
  Cicero, *de Divinatione.*
  „ *de Natura Deorum.*
  Latin verse, and Greek prose and verse composition.
I. Moral Philosophy.
II. Natural Philosophy, both mathematical and experimental.
III. Pure Mathematics:—
  Integral Calculus, and Differential Equations.
IV. Mental Philosophy, and Elements of Political Economy and Philosophy of Right.

Note 1.—The examination in the Greek and Latin Classics includes Greek and Roman History in outline, and Latin Prose Composition

Note 2. The works prescribed in the classical part of the Examination may be changed in the case of any of the affiliated Students for equivalent matter, on a communication being addressed to the Rector of the University by the Head of the College in which the students reside.

OCTOBER, 1872.

1 T Anatomical Dissections commence in the School of Medicine.
2 W *Feast of the Holy Guardian Angels.*
3 Th
4 F *St. Francis of Assisium.*
5 S
6 𝔖 XX. *after Pent*
7 M
8 T
9 W
10 Th
11 F
12 S
13 𝔖 XXI. *after Pent* Dedication of the Churches of Ireland.
14 M Entrance Examination. Junior Classical Exhibitions.
15 T Entrance Do. Do.
16 W Senior Classical Exhibitions.
17 Th Do. Do.
18 F Mathematical Exhibitions. Junior and Senior.
19 S Do. Do.
20 𝔖 XXII. *after Pent.* High Mass and *Veni Creator* at the commencement of the Session
21 M Conolly Exhibition for Natural Philosophy. Lectures begin.
22 T Conolly Exhibition for Chemistry. Lectures.
23 W Limerick Foreign Languages Exhibition. Lectures.
24 Th Cloyne Exhibition for Irish. Lectures.
25 F Limerick Exhibition for English. Lectures.
26 S Cloyne Exhibition for Logic and Mental Science. Lectures.
27 𝔖 XXII. *after Pent.*
28 M *SS. Simon and Jude, Apostles.* Lectures.
29 T Lectures.
30 W Lectures.
31 Th ALL HALLOWS EVE. *Fast.* Lectures.

NOVEMBER, 1872.

1 F ALL SAINTS.
2 S *Commemoration of all the Faithful Departed.* Lectures. Michaelmas Law Term begins.
3 𝔖 XXIV. *after Pent.*
4 M Lectures.
5 T Lectures.
6 W Lectures.
7 Th Lectures.
8 F Lectures.
9 S Lectures.
10 𝔖 XXV. *after Pent.* *Patronage of B.V.M*
11 M Lectures.
12 T Lectures.
13 W Lectures.
14 Th *St. Lawrence O'Toole.*
15 F Lectures.
16 S Lectures.
17 𝔖 XXVI. *after Pent.*
18 M Lectures.
19 T Lectures.
20 W Lectures.
21 Th *Presentation of B.V.M.* *Lectures*
22 F Lectures.
23 S Lectures.
24 𝔖 XXVII. and last *after Pent.*
25 M Lectures.
26 T Lectures.
27 W Lectures.
28 Th Lectures.
29 F Lectures.
30 S *St. Andrew, Apostle.* Lectures.

DECEMBER, 1872

1 𝔖 I. *of Advent.*
2 M Lectures.
3 T *St. Francis Xavier.* Lectures.
4 W Lectures.
5 Th Lectures.
6 F Lectures. *Fast.*
7 S *St. Ambrose.* Lectures. *Fast.*
8 𝔖 II. *of Advent.* Immaculate Conception B.V.M.
9 M Lectures.
10 T Lectures.
11 W Lectures.
12 Th Lectures.
13 F Lectures. *Fast.*
14 S Lectures. *Fast.*
15 𝔖 III. *of Advent.* Celebration by the University of the Immaculate Conception B.V.M., Patroness of the University.
16 M Lectures.
17 T Lectures.
18 W Terminal Examinations begin *Fast.* *Quarter Tense.*
19 Th Examinations.
20 F *Fast.* *Quarter Tense.*
21 S *Fast* *Quarter Tense.* ST. THOMAS, *Apostle.* (Michaelmas Term Ends.)
22 𝔖 IV *of Advent.*
23 M
24 T *Christmas Eve.* *Fast.*
25 W CHRISTMAS DAY.
26 Th ST. STEPHEN, *Proto-Martyr.*
27 F ST. JOHN, *Apostle and Evangelist.*
28 S HOLY INNOCENTS.
29 𝔖 *St. Thomas of Canterbury.*
30 M
31 T *St. Sylvester.*

NAMES OF THE SUCCESSFUL COMPETITORS FOR THE LAST THREE YEARS.

MEDICAL EXHIBITIONS AND GOLD MEDALS.
1868 69.

Gold Medal.

In Surgery, Medicine, and Midwifery combined—Boyd, Michael A. (Co. Roscommon).

Conolly Exhibition in Physiology, Chemistry, and Botany—Kilbride, John (Queen's Co.).

University Gold Medals in Practical Chemistry, Materia Medica, and Medical Jurisprudence. (N.B.—A second medal was awarded on account of the special merit of the candidates: M'Carthy, Charles (Co. Tipperary); Roche, Anthony (Dublin).

Special Prize, Furlong, Nicholas (Co. Wexford).

1870-71.

University Exhibition in Medicine, Surgery and Midwifery—Kilbride, John.

Conolly Exhibition in Anatomy, Physiology, Chemistry, and Botany—Mulvany, Edward.

University Exhibition in Practical Chemistry, Materia Medica, and Medical Jurisprudence—M'Kenna, Thomas Thornton.

1871-72.

Conolly Exhibition, Medical, in Physiology, Chemistry, and Botany—M'Donald, Denis P.

University Gold Medal, in Practical Chemistry, Materia Medica, and Medical Jurisprudence—M'Donald, Denis P.

EPISCOPAL EXHIBITIONS.

Faculty of Philosophy and Letters, and of Science.

Entrance, 1869-70.

Classical (20*l.*), O'Connor, George (St. Ignatius' College, Galway).
" (15*l.* each), O'Connor, Patrick (Do., Do).
Butler, Michael (French College, Blackrock, Co. Dublin).
" (10*l.* each), Doheny, James. (Do., Do.)
Cosgrove, Philip (Do., Do.)
Mathematical (20*l.*), Gleeson, Michael (Killaloe Diocesan College).
" (15*l.* each), Cosgrove Philip (French College, Blackrock, Co. Dublin).
Moylan M. J. (St. Ignatius' Coll., Galway).
" (10*l.*) O'Meara, M. S. (County Dublin).

Second Year's Exhibitions.

Classical (20*l.*), O' Doherty, John H. (Co. Fermanagh).
" (15*l.*), Kenny, Charles (French College, Blackrock, Co. Dublin).
Mahony, Martin (Do., Do).
" (10*l.*), Cox, Michael (Co. Roscommon).
Atkinson, William (Co. Longford).
Mathematical (10*l.*), O'Doherty, John H. (Co. Fermanagh).
" (15*l.*), Fottrell, John E. (Co. Dublin).
" (15*l.*), Kelly William (Co. Kilkenny).
Atkinson, William (Co. Longford).

Junior Exhibitions.—First Year, 1870-1.

Classical (20*l.*), M'Donald, Denis Peter.
" (15*l.*), Griffin, Patrick Thomas, French College, Blackrock.
M'Evoy, Thomas Do. Do.
" (10*l.*), Quin, John, French College, Blackrock.
M'Gucken, Robert, Do. Do.

Second Year.

Classical (20*l.*), O'Connor, George.
" (15*l.*), O'Connor, Patrick.
Cosgrove, Philip.
" (10*l.*), Doheny James C.
Cox, Thomas.

First Year.

Mathematical (20*l.*), Hogan, Denis.
" (15*l.*), M'Donald, D. P.
M'Alister, James.

Second Year.

" (20*l.*), M'Cormack, Edward A.
" (15*l.*), Gartlan, Alexander.
Cox, Thomas.

Senior Exhibitions.—Third Year

Classical (15*l.*), Cox, Michael.
Atkinson, William.
" (10*l*)., Kenny Charles.
Mathematical (20*l.*), Atkinson, William.
Classical (40*l.*), Gallagher Francis.
Classical (30*l.*), O'Doherty, John H.
Mahony, Martin.

Irish (20*l.*), Cox, Michael.
English (20*l.*), Cox, Michael.
French (20.), M'Donald, D. P.
Mathematical (10*l.*), Fottrell, John Edward.
" (30*l.*), O'Doherty, John H.

Entrance—1871-72.

Classical (20*l.*), O'Carroll, John F., C. U. Sch., Dub.
" (15*l.*) each, Brennan, Nicholas, French College.
Griffin, Gerald F., French College.
" (10*l.*) each, Bodkin, Matthias, Gayfield.
Hartford, John P., Gayfield.
Daly, Patrick A., C. U. Sch. Dub.
Collier, A. T., St. Mary's, Dundalk.
Mathematical (20*l.*), O'Carroll, Joseph, C. U. School.
" (15*l.*) each, Monaghan, Thomas.
Daly, Patrick, A. C. U. School.
" (10*l.*) each, Griffin, Gerald, French College.
Brennan, N., French College.

Second Year's Exhibitions.

Classical (20*l.*), Quinn, John.
" (15*l.*) each, Griffin, P. T.
M'Cabe, John.
" (10*l.*), M'Alister, James.
Mathematical (15*l.*), M'Alister, James.

Third Year's Exhibitions.

Classical (15*l.*), Butler, M.
Cox, Thomas.

CONOLLY EXHIBITIONS.

1869-70.

Natural Philosophy, Gallagher, Francis (Co. Donegal).
Mathematical, Dillon, William (Co. Dublin).

1870-71.

Natural Philosophy, Atkinson, Wm. (Co. Longford).

1871-72.

Chemistry, Atkinson, Wm. (Co. Longford).

CLOYNE AND LIMERICK EXHIBITIONS.

Cloyne Exhibitions, 1869-70.

Irish (20*l.*), Gallagher, Francis (Co. Donegal).
Logic (20*l.*), Williamson, George (Co. Dublin).
Classical (30*l.* each), Williamson, George (Co. Dublin).
Gallagher, Francis (Co. Donegal).

Limerick Exhibitions, 1869-70.

Classical (40*l.*), Dillon, William (Co. Dublin).
Mathematical (40*l.*), Dillon, John (Co. Dublin).
" (30*l.*), O'Doherty, John H. (Co. Fermanagh).

Modern Literature (20). O'Doherty, John H. (Co. Fermanagh).

University Gold Medal for Mathematics—(Being the highest Mathematical distinction in the University)—Dillon, John (County Dublin).

Limerick Exhibition, 1870-71.

Classical (40*l.*), Francis Gallagher (Co. Donegal).

Cloyne Exhibitions.

Classical (30*l.*), 1 John H. O' Doherty (Co. Fermanagh).
2 Martin Mahony.

Cloyne Exhibition.

Irish (20*l.*), Michael Cox (Co. Roscommon).

Limerick Modern Literature Exhibitions.

English (20*l.*), Michael Cox (Co. Roscommon).
French (20*l.*), D. P. M'Donald (Co. Cork).

Limerick Exhibitions.

Mathematical (40*l.*), 1 John Edward Fottrell (Dublin).
" (30*l.*), 2 John H. O'Doherty (Co. Fermanagh).

Cloyne Exhibitions, 1871-72.

Irish (20*l.*), Cox, Michael.
Logic (20*l.*), Atkinson, William.
Mental Science (20*l.*), Callinan, Michael.
Classical (20*l.*), Dillon, Wm. (Co. Dublin).

Limerick Exhibitions, 1871–72.

Mathematical (40*l.*), O'Doherty, John H.
,, (30*l.*), Atkinson, William.
,, (20*l.*), Fottrell, John E.
Modern Language and Literature (20*l.*), Cox, Michael.

Exhibitions for Students of Approved Colleges and Schools, 1868–69.

Classical.

Magner, Patrick, St. Vincent's, Cork.
Murphy, James, French College, Blackrock.
Campbell, Arthur, University School, Waterford.

Mathematical.

Moriarty, James, French College, Blackrock
Sheehan, P.A., St. Colman's, Fermoy.

1869–70.

Classical.

Butler, Michael, French College, Blackrock
Moriarty, John, St. Brendan's, Killarney.
Gartlan, Alexander, St. Stanislaus', Tullamore
Murphy, Richard J., St. Vincent's, Cork.

Mathematical.

Barrett, Richard, St. Vincent's, Cork.
Cosgrove, Philip, French College, Blackrock.

1870–71.

Classical, Hurley, William, French College, Blackrock.
Mathematical, Cosgrove, Philip, French College, Blackrock.

PRIZES.—1871.

Latin Prose:—Flight of the Earls of Tyrone and Tyrconnell.
First, Butler, Michael, French College, Blackrock.
Second, Bechesell, James, Rockwell.
Greek Verse:—Athene Polias.
First, Mulleady, Daniel, French College, Blackrock.
Latin Verse:—Ion.
Second, Mulleady, Daniel.
English Essays:—Life and Times of Frederick II
First, M'Alister, James.
Second, M'Donald, M., Rockwell

1869.

Greek Prose:—Thucydides.
First, O'Connor, George, St. Ignatius' College, Galway
Second, Murphy, J., French College, Blackrock.
Latin Verse:—Perseus.
First not awarded.
Second, Counihan, Timothy, French College, Blackrock
Latin Prose:—Henry Grattan.
First, Counihan, Timothy, French College, Blackrock
Second, O'Connor, Patrick, St. Ignatius' College, Galway.
English Essay:—Charlemagne.
First, Tighe, Thomas, J. P., Rockwell College.
Second, Donnelly, D. J., do.

1870.

Greek Essay.
First, O'Connor, George, St. Ignatius' College, Galway
Second, O'Connor, Patrick, do. do.
Greek Verse:
Second, Kennedy, M., French College, Blackrock
Latin Essay
Second Prize, Butler, Michael, French College, Blackrock, and
O'Connor, Patrick, St. Ignatius' College, Galway
Latin Verse:
Second, Hunter, W. J., French College, Blackrock
English Essay
First, O'Connor, Geo., St. Ignatius' College, Galway
Second, M'Evoy, Thos., French College, Blackrock

Instructions for Students desirous to enter the University as Interns or Externs resident in Dublin.

Students may enter the University as Interns or Externs in any of the three Faculties of Philosophy and Letters, of Science, or of Medicine.

With the permission of the Rector and on payment of the proper fees, any person may attend the Schools of the University or any particular course of lectures. Such persons are called Auditors, and in the Faculty of Medicine there are many such. Except in the lecture room, they have no connexion with the University, which is not responsible for their conduct or their success in their studies. However, for special reasons, Auditors may be allowed to reside in a collegiate house or in one of the lodging-houses approved for students by the University, provided they submit themselves to the regulations prescribed for those places, and put themselves under the moral care of the University.

In order to become formally Students, and consequently members of the University, and entitled to all its privileges, the candidates for admission must place themselves under its guidance and discipline.

The entrance or matriculation examination must be first passed.

Entrance or Matriculation Examination.

All University Examinations are conducted both orally and in writing.

The qualification in point of learning required for entrance to the University is about the same as is needed for entering the class of "Rhetoric" in our Catholic Colleges. However, in order that the greatest advantage may be derived from the teaching of the University, it is necessary that the candidate should be able to pass creditably for the Rhetoric Class. And the greater his knowledge of Classics and Mathematics, the greater will be the fruit derivable from following Lectures in the University.

Each candidate must be at least sixteen years of age, and must be recommended by the person who last had charge of his education, and by his bishop or by one of the clergymen of his parish. He presents himself, in the first place, to the Rector or his representative, by whom he is authorised to offer himself for examination.

Candidates for entrance are examined;

1. In the Christian Doctrine.
2. In any one Greek and any one Latin book, of their own selection, from the following entrance List:

Greek.

Homer's Iliad, any three books.
Sophocles, any play.
Euripides, any play.
Herodotus, any book.
Xenophon, Cyropaedia or Anabasis.
Plato, Apologia Socratis.
Lucian, Walker's Selections.

Latin.

Virgil, Georgics, any two books.
,, Æneid, any three books.
Horace, Odes, any two books.
,, Satires or Epistles.
Cicero, Select Orations, viz., [illegible] Catilinam i., iv., or any three others.
Livy, Books i., ii., iii., [illegible]

3. They are further examined in,

Arithmetic.
Algebra, as far as Simple Equations inclusively.
Euclid, Books i., ii.
English Composition.
The rudiments of French.
The elements of Ancient and Modern History.
The elements of Modern Geography.
Latin Prose Composition.

Upon passing the Examination, the Candidate for Entrance receives a Certificate signed by the Examiners, which he presents to the Secretary of the University, to whom he pays the usual fees. Subsequently, on the appointed day, the Rector inscribes his name in the University Register, and he thereupon becomes a Student of the University. Previous to the insertion of his name in the Register, he promises to obey the authorities and to observe the Rules and Statutes of the University.

When entered, he becomes at once an Intern or Extern Resident Student of the University. At the same time he informs the Rector or Dean of the special object he has in view in entering the University, and of the branches of learning to which he consequently wishes to apply himself in a special manner. In the choice of lectures he will be directed by the Rector or his representative.

Students in Medicine will be directed by the Dean or Secretary of the Medical Faculty as to the course of studies they will follow with the greatest advantage.

Students aspiring to the Ecclesiastical state will devote themselves specially to the study of Logic, and of Mental and Moral Philosophy, under the direction of the Professor of Logic.

Students of Engineering, before commencing their strictly professional studies, ought to possess a satisfactory knowledge of the subjects included within the first two years of the University course in Arts. It is particularly necessary that they be well acquainted with Mathematics, Natural Philosophy, and General Chemistry. To those they must add a thorough practical knowledge of Drawing in all its branches, and a familiar acquaintance with French.

In the case of Mining Engineering, the Student should also possess a knowledge of Practical Chemistry.

Extern and Intern Students.

The resident students of the University are divided into externs and interns.

Extern Students are of two classes :

1st. Those who live with their friends in Dublin or its neighbourhood, and attend the University Lectures. They are required to be present at the University Mass on Sundays and Holidays, to approach the Sacraments of Penance and Holy Communion, and to lead good Christian lives.

2nd. Those who live in lodging-houses approved by the University. They are required to observe the Rules of such Houses, and especially with respect to keeping regular hours, to attendance at the University Mass on Sundays and Holidays, and frequentation of the Sacraments. They are under the superintendence of the Vice-Rector or Senior Dean, to whom they, as well as the other externs, are amenable in case of violation of rule or misconduct. The Vice-Rector or Senior Dean will, on application, furnish lists of the approved lodging-houses; but the University does not interfere in any way as to the charges for lodging, etc., which, of course, vary according to locality, to the student's habits, and to other circumstances.

Intern Students are such as reside in one of the University Houses in Dublin. They must observe the Rules of the House in which they reside, otherwise they may be directed by the Dean to withdraw from it. There are at present two such houses. The students of both enjoy the same rights and privileges in the University. The details of discipline vary in each; but all agree in requiring the students to attend night and morning prayer, and to frequent the Sacraments, and in obliging to be in-doors at dusk, unless by the special permission of the Dean, which is given only for grave reasons. The terms vary in each house, and can be known by application to the respective Deans, who will also explain the rules of the house, which every student on entering must promise to observe.

UNIVERSITY HOUSES.

St. Patrick's House, Stephen's Green, South.

Dean—Rev A. O'Laughlin.

The Students of this house are permitted to arrange their hours as they please, under the direction of the Dean. They are required to attend their religious duties above-mentioned, and daily Mass, to rise at an early hour, to be indoors at nightfall, and to take their meals in the house.

Each Student has, as far as possible, a separate room; and the rent of the room (furnished) for the University Session of nine months varies from 7*l.* 10*s.* to 15*l.*, payable in advance in three instalments. This sum includes attendance and fire and candle light. The House does not supply bed clothes, etc.

The expenses of a Student, over and above Lecture fees and the charge for lodging, are not regulated by the University, and will, of course, vary with the habits of the individual. Extravagance will not be allowed. Arrangements are made, through which the greatest economy can be practised, and, as a general rule, a Student's personal expenses need not exceed 10*s.* a week, or about 20*l.* for the scholastic year.

The total expenses of a Student in St. Patrick's House, including lodging, board, and University fees (in Arts), need not, if economy be practised, exceed 40*l.* a year.

Our Lady's House, 89, Leeson Street.

Under the Fathers of the Society of Mary.

Superior—V. Rev. J. Leterrier, S.M.

This house being chiefly, although not exclusively, intended for Ecclesiastical Students, its discipline is more strict. Students residing in it are required to rise at an earlier hour, and to attend daily meditation and Mass, and they are not allowed to leave the precincts, except to go to the lectures of the University, without special permission each time from the Dean.

Terms—Forty guineas a year. This sum includes board, lodging, and University fees (in Arts).

Affiliated Students.

Besides the students resident in Dublin, the University has Affiliated Students.

Affiliated Students are those who, after having passed the Entrance Examination in the University, or elsewhere, before an University Examiner, have been enrolled on the books of the University, and pursue their studies in an approved College or School with the view of completing the higher studies in the University.

They are examined at the end of each academical year by an University Examiner, who will visit the Colleges and Schools connected with the University in July, or at any other convenient time, for the purpose of examining these students.

The subjects for the Examination are mentioned in the University Calendar.

EXAMINATION DAYS, &c., OCTOBER 1872.

The University Session, or Academical Year, begins on the day after the second Sunday in October.

Entrance Examinations will be held during the Second Week of October, commencing on Monday, 14th October 1872, at 10 a.m., and on each succeeding day of the week at the same hour.

Catholic University, Dublin,
April 10, 1872.

On CRAMMING for EXAMINATIONS, and on the RELATIVE MERITS of ORIGINAL WORKERS at SCIENCE and MERE BOOK-MEN. Extracted from a *Discourse on the Study of Science in its relations to Individuals and to Society*, by HENRY HENNESSY, F.R.S., M.R.I.A., Formerly Professor of Natural Philosophy in the Catholic University of Ireland.

(See Question **13,506**, Vol. II., pp. 337–8.)

THE direct application of knowledge to the practical purposes of life which constitutes professional information, is not the only circumstance by which it induces us to engage in its pursuit. Some are attracted to study from a natural desire to become well-qualified members of cultivated society; to others the pursuit of knowledge affords relaxation and change of mental exercise in the intervals permitted by the active duties of life; those to whom fortune has accorded the leisure accompanying affluence, will sometimes wisely grasp the opportunities which intellectual occupation affords for flying the tortures of mental inactivity. Besides all these, there exists a smaller number of inquirers, who pursue knowledge chiefly on account of its unspeakable excellence. To them knowledge appears almost like virtue, a good in itself, not the means, but the end. To them no difficulties in its search are overwhelming, no step in its pursuit is too toilsome; their attention is so steadily turned towards the light dawning in front, that they scarcely notice such asperities as they may encounter on the path over which they are treading. No proposition is more manifestly true, than that the closer every seeker after knowledge approaches to this type, the more likely is he to find successful fruition attendant upon his search. Happy are those who, while anxious to achieve extraneous objects by the aid of knowledge, are, at the same time, inspired with attachment to the instrument by which the attainment of such objects is to be fulfilled. No method of pursuing knowledge can, therefore, be deemed entirely rational, which does not in some measure tend to bring the mind into the condition of that of an earnest votary who is impelled towards its pursuit independently of all other considerations than the excellence of the object itself.

The knowledge acquired under such circumstances will generally be more healthy and profound, than when the stimulating action arises from other causes. Professional knowledge, it will be urged, may be successfully acquired, not on account of any intellectual pleasures that may accompany its cultivation, but solely for the honourable independence it confers. But in the exercise of a profession, sound knowledge is alone available, imperfect knowledge exposes its possessor to failure and ridicule. In his practice at a profession, a superficial student would soon find the narrow boundaries within which his acquirements could be useful, and he would be constantly overwhelmed with difficulties which his limited stock of ideas and his feeble power of applying them would render him unable to surmount. This follows from the essentially empirical nature of superficial knowledge.

In the practical applications of science superficiality is generally worse than useless. Why are the archives of the Patent Office filled with innumerable specifications of sterile inventions? Why have so many hopeful speculations regarding the extraction of mineral wealth from the recesses of the earth been attended with ruin to their projectors? Why are minds sometimes overturned, even to this day, in vain searches after self-acting, perpetually moving agents which should endow us with powers far greater than those fabled in the flights of oriental imagination? All such results follow from the superficial acquirements and imperfect mental preparation of persons who enter upon a struggle wherein great difficulties are to be conquered, but for which they have never been provided with suitable weapons, nor properly exercised in the management of such arms as they may happen to possess. Even in cases where no utilitarian results are the professed object of study, the position of a superficial student is scarcely to be envied. He may, perhaps, desire to appear highly learned among his acquaintance, and with far-seeing economy may strive to purchase his reputation at the smallest cost at which it can be procured. He skims rapidly over a wide extent of subjects, and attributes his haste to the constant necessity of affording fresh food to a mind at once so delicate and so voracious. His crude acquisitions appear to him as a mass of varied and extensive information; his all-grasping intelligence seizes upon the most diverse questions of literature and science. He can talk of the structure of an obscure language spoken in the centre of Africa, and tell the exact weight in tons of a remote planet. He reflects that such facts were unknown to the greatest sages of antiquity, and even to some of the philosophers of modern times. Elated by his supposed superiority in enlightenment, he is liable to form the most erroneous impressions as to his own capacity. Instead of being illumined in his progress by the steady light which accompanies the cautious and humble spirit of true inquiry, he is deeply immersed in the impenetrable haze arising from his own self-delusions. Like a steam-vessel proceeding at a reckless speed in the midst of a fog, he is in constant danger of meeting with a disastrous collision. His self-love may at any moment receive a fatal wound by finding that he had been exposing his own blunders, when he had imagined that he was covering himself with glory.

Those who have unexpectedly acquired riches, are usually not the most judicious in the application of their sudden wealth, nor the most self-restrained in the feelings of exultation which so often accompany the possession of a much larger share of the goods of this world than happens to fall to the lot of the majority of men. A great mass of knowledge, unlike riches, is incapable of sudden acquirement. No person can become learned by family inheritance, nor can he win science as in a lottery. But superficial knowledge may be acquired with comparative rapidity, and hence arises one of its greatest dangers. This is the peculiar form of vanity already noticed, a quality not only morally injurious, but highly obstructive to future progress. A venerable writer remarks that an humble husbandman, who serves God, is much better than the proud philosopher who, neglecting himself, studies the stars. He might have added, that had the humble husbandman and proud philosopher changed places, with equal abilities the former would be far more likely to advance knowledge than the latter. Every true philosopher must be at the same time an humble philosopher, or he forfeits his claim to the appellation.

The quality which is now considered as so strongly opposed to the humility of true wisdom, impedes the progress of intellectual improvement, first by the natural result of a complacent reflection upon our acquisitions, by which we are induced to remain contented with our achievements. But it accomplishes the same result in another way, scarcely less fatal, though far from being so obvious. This arises from the confusion that so frequently exists in the minds of superficial students as to the merits of original thinkers, and those which are assigned to the accumulators and dispensers of knowledge. Unlike Napoleon, who, when he heard any man's talents highly vaunted, promptly demanded, "What has he done?" the superficial student is liable to judge of others as he does of himself, not by what they have performed, but by what they can say respecting the performances of their predecessors. Nothing can be more fatal in the relations, not only of individuals but of society at large, to the progress of true knowledge, than any confusion between the abilities required for the advancement of science, and those very inferior and common-place powers that suffice for its comprehension. Who would place on the same level with Columbus the ordinary mariner who now safely steers his ship across the Atlantic? Yet it is from a blunder of this kind that the superficial student is occasionally, not only liable to regard his own imperfect acquirements with too much complacency, but to forget that what little he does know, may be due to the labours of men who lived in less enlightened ages, and upon whom, consequently, he is apt to look with pity and contempt. The glory of what his instructors and guides may have achieved, unaided by the advantages in his possession, instead of being greatly enhanced by the difficulties conquered, is in his shallow apprehension considerably obscured. Such a frame of mind inevitably leads a student to a wrong choice when selecting the instruments of his intellectual progress, and it induces him to accept of erroneous methods when employing these instruments as means of mental cultivation.

Instead of striving to gain something of the ennobling influence exercised by productive minds when developing ideas which are to form additions to the stock of human knowledge,—instead of drinking deeply at the fountain-heads of science in the writings of original authors, he satisfies his thirst in the waste and sometimes turbid waters that have trickled aside. His object being not to know, but to seem to know, he endeavours to reach science by short cuts. He disregards Euclid's answer to Ptolemy, and firmly believes that there are not only royal but even plebeian roads to learning. Compendiums, and every other device of bookmaking skill, possess in his eyes more merit than any other productions. According to an expression unfortunately too often applicable in these days, he endeavours to *cram* himself. If aided in this operation by a teacher, the results will be but little different, except that the impression of a bad system shall be more intense, from the influence exercised on his mind by a person on whose judgment he may have been accustomed to rely.

Here it may occur to many to ask whether it is not true that in the higher departments of science and learning the greatest lights are, in fact, the least fitted to illuminate the student's path, whether by their writings or by their direct personal influence. This question could not arise but for the fallacies which a certain class of educationists are constantly endeavouring to propound, and as these fallacies seriously affect not only the speculative results, but the practical ends of all education, their formal confutation becomes of considerable importance.

Dr. Whewell, in his writings on University Education, enumerates certain works as those which contain the most complete methods and the most finished results of science. These he calls capital works, and they are all of the highest order, and such as only very advanced students could possibly use. To these I would add some others, which might be called capital works of the second order, because they can be studied with less previous preparation than those of the first order. But they possess some common characteristic properties,—they are the products of original thinkers, and they sometimes contain the germs or the developments of discoveries.

Even as Dr. Whewell has named a few capital works of the first order, such as the *Principia* of Newton and the *Mécanique Céleste* of Laplace, I may suggest a few of the second order, such as that book which is usually placed in our hands at the very beginning of our geometrical studies, and that treatise upon a fundamental department of mechanics with which a living French mathematician has enriched the armoury of education, while shedding an entirely new light upon some of the most general laws of matter.

Those who maintain the inability of original inquirers to assist in the diffusion of knowledge, because they happen to be employed in its advancement, rarely appeal to facts, because facts preponderate strongly against them. What teachers communicated to their pupils not only the objective truths, but also the living subjective influence of scientific thought, so completely as the sages of Athens and Alexandria? The crowded porticoes and gardens of the Academy did homage to the elevating influence of original ideas as they sprang from the minds of Plato and Aristotle.

During the middle ages, what teachers attracted more students, than they who were most active by their works in reviving and cherishing the fire of intellectual activity? In recent times, where were some of the newest sciences of the day cultivated with greater enthusiasm, and to what kind of influence did the crowded schools of Friberg and Giessen attest? Who were the men that the organizer of science as well as of victory gathered together under the first French republic, in order to form by far the most perfect school of mathematical science the world has ever seen—were they merely adepts in a system of routine?

Their names are registered on many a bright page of the history of science. Lagrange, Laplace, Monge, Legendre, Berthollet, have exercised an influence on the diffusion of scientific knowledge as well as on its advancement, which mainly confers on France the proud scientific position she occupies.

Only two months have elapsed since a quiet country town in England witnessed within its precincts a brilliant assemblage gathered together by a common sentiment of veneration for the memory of him whose name is associated with the greatest discoveries that the human mind has yet been able to achieve. Among those who were so assembled, none were, assuredly, better entitled to take a part in the proceedings of the day than the members of that University whose attachment to science and whose earnest cultivation of exact knowlege is famed all over the world. The impulse was certainly not attributable to a Mr. Uvedale, who nearly two centuries before had defeated in an examination for fellowship a competitor known by the name of Isaac Newton.

Routine educationists will meet with other events similarly hurtful to their feelings, if they carefully study the history of literature and science. I have heard such an educationist, who happened to possess a position of authority, maintain opinions that, logically carried to their practical application, would effectually obstruct the growth of sound knowledge in every seminary of learning. "A mathematician," said he, "may discover some new results, or extend the boundaries of science, but the public cannot immediately judge as to the merits of what he has done; whereas a solid distinction, such, for instance, as colleges can confer, may be promptly appreciated by the meanest understanding; consequently it is our best policy, whenever we desire to attract the multitude to the fountains of knowledge, to arrange that those by whom science is to be imparted, should possess rather the tangible than the speculative class of distinctions." You will perceive that this gentleman was disposed to proceed even a step further than the superficial student, who was in danger of confounding a higher order of mental power with an order much inferior, for in this instance the inferior power was avowedly preferred, through motives of profound and generous policy. But if the views of the public upon such matters were such as have been attributed to them, which I deny, no stronger illustration could be adduced of the evils springing from superficial knowledge, than such a reaction upon the minds of those who aspire to be the guides of popular taste in questions of education, as would induce them to disregard principles in order to conform to the prejudices of the multitude.

While combating the erroneous principles of the routine class of educationists, let me not be supposed to rate a certain class of distinctions below their just value. Proofs of the possession of real knowledge are always honourable to him who can fairly exhibit such proofs, although the widest range exists between the different degrees of merit which may be demonstrated by the varying nature of the evidence. Hence has arisen the principal difficulty in the employment of the system of competitive examination as a test of capacity for persons entering the public service. The only way in which such a difficulty can be obviated or eluded, is manifestly by freeing such examinations as much as possible from the influence of routine educationists, by selecting examiners and framing the entire scheme of examination on such principles as to test intellectual power and not mere acquired information.

From all the foregoing remarks it will be readily seen that I do not confound superficial knowledge with a little knowledge. The distinction between sound and imperfect knowledge is one of quality and not of quantity. Inattention to this obvious circumstance has probably created the misconceptions to which allusion was already made. One individual may possess but a little knowledge, and yet that may be very sound; while another person may have acquired extensive but shallow information on all things knowable. A student may glide superficially over several great departments of science or literature, acquiring an abundance of misarranged and undigested ideas; while another may simultaneously make himself thoroughly acquainted with a limited portion of the same subjects. We cannot confound the extensive superficial acquirements of the first with the fewer but more solid attainments of the second. We cannot fairly designate the kind of knowledge possessed by both in the same terms. A little of wholesome food is usually not dangerous to the body; but much or little of bad food is decidedly hurtful. In like manner, a little knowledge is not dangerous on account of its limited extent, while imperfect knowledge, whether little or much, will be dangerous on account of its quality. The beginnings of knowledge must be little, but they are not consequently dangerous.

A qualitative rule for distinguishing between superficial and real knowledge seems to be suggested by the preceding reflections. Any knowledge is profound, which enables its possessor to form an independent judgment respecting the validity of the several steps of reasoning by which that knowledge became established in his mind. Thus, a student possessing a thorough acquaintance with certain geometrical truths, could easily assure himself of the correctness of the methods employed in astronomy for ascertaining the distance of a planet, and for distinguishing its real from its apparent motions. Another person, unprepared by the discipline of geometrical study, and unaided by the powerful instrumentality of its results in the task of consolidating his acquirements, might obtain a general knowledge of the endlessly varied phenomena presented by the heavens, without being able to clearly perceive the difference between the true and apparent motion in the case of a body which comes most prominently under his observation.

As superficial knowledge is the opposite of profound, it may be defined as such as will not enable its possessor to form an independent opinion as to the soundness of the reasonings on which his acquirements are based. Although endless varieties of an intermediate kind must exist, the distinction here drawn may prove not altogether useless. The fallacy of the distinguished orator * already alluded to, arose from confounding shallowness with limited extent of knowledge. While labouring under such a delusion, it is not surprising that he should suppose that Newton would acknowledge himself as a smatterer in comparison with a boarding school girl of our day. Yet this strangely amusing fallacy was propounded by the same writer, who not long afterwards, in his brilliant History of England, paid a tribute of reverence and admiration to the memory of those who shed so much lustre over the reigns of the later Stewarts, by their additions to the conquests of mind over matter, and among which, as well as among all names that the page of history has ever unfolded, the name of Newton shines with transcendent glory.

---

* Lord Macaulay.

APPENDIX VII. (See Questions **10,316–17**, Vol. II., pp. 75, 76.)

COMMUNICATIONS from Lieut.-Col. ALEXANDER STRANGE, F.R.S., and PROFESSOR CAYLEY, F.R.S., relating to the proposed establishment of a PHYSICAL OBSERVATORY.

SIR, London, November 1, 1872.

IN the evidence which I gave before the Royal Commission (April 24th, 1872, Qu. 10,316-17), I dwelt on the necessity for providing for the Systematic Cultivation of the Physics of Astronomy, and gave it as my opinion that a distinct and separate observatory should be founded by the State for the purpose. I pointed out why such researches could not be advantageously carried out at the Royal Observatory, Greenwich.

Since then, a good deal of discussion on this subject, provoked by me, has taken place at the Royal Astronomical Society. Seeing the tendency of influential opinion, I felt it necessary to justify my position by obtaining in writing the views of those who are at once independent and competent authorities of the highest order. I therefore addressed definite questions to the following distinguished men of science:

Professor Hilgard, U.S. Coast Survey.
Dr. Balfour Stewart.
Sir W. Thomson.
M. Faye, President of the Paris Academy of Science.

The replies with which these gentlemen have favoured me constitute so strong and consistent a body of evidence on the subject, that I feel it my duty to lay them before the Commission. I therefore beg now to enclose them, together with my questions which elicited them.

It will be seen that my fifth question is addressed to M. Faye only. I would explain that I sent the first four questions to the other three gentlemen, as the dates will show, before the publication, on the 1st of June, of the Astronomer Royal's Report for the present year to the Board of Visitors. In that document Sir George Airy indicates the provision which he considers sufficient for the cultivation of Astronomical Physics, and he undertakes to make this provision at Greenwich. I was so struck with the inadequacy of his proposed arrangements, that, in addressing M. Faye, I added my question 5 in order to obtain a direct opinion from that eminent man as to whether such researches could or ought to be engrafted on the work of meridional observers. It appears to me that M. Faye's reasoning on the subject is quite unanswerable, and it is satisfactory to me to find that the intellectual difficulty pointed out by me in my evidence before the Royal Commission is that on which he lays the greatest stress. When we reflect on the fact that no one man has yet distinguished himself in both the ancient and the modern branches of Astronomy, we are irresistibly impelled to conclude that the same order of genius is not applicable to both.

I would point to the contrast between the conceptions of my distinguished correspondents and that of the Astronomer Royal, who will undertake sunspot photography only, is "in doubt" as to solar spectroscopy, considers one additional assistant sufficient for astronomical physics, and thinks that "possibly in time" the operations of Greenwich "might be extended still further in a physical direction."

The tone of this portion of the Astronomer Royal's Report is that of one who is driven by extraneous pressure to undertake that for which he has not much inclination or taste, and from which he is doubtful whether any useful result will follow.

I regret to be opposed to one for whose character and genius I feel nothing but regard and admiration; but, in the present instance, being satisfied that Sir George Airy has failed to grasp the requirements of this branch of science, I cannot refrain from laying before the Royal Commission opinions which, on this particular subject, must rank higher than his, in order to prevent, if possible, the adoption of a course which must fatally obstruct scientific progress.

I have, &c.,
The Secretary, ALEX. STRANGE, Lieut. Col.
Royal Commission on Science.

Circular addressed to—

Professor Hilgard, May 15
M. Faye, Ac. des Sciences, June 22
Sir W. Thomson, } May 28
Dr. B. Stewart, }

DEAR SIR,

I SHOULD be very much obliged if you would favour me with your opinions on the following points:—

(1.) Is the systematic study of the solar constitution likely to throw light on subjects of Terrestrial Physics, such as Meteorology and Magnetism?

(2.) What means, at present known to Science, are available for studying the sun?

(3.) Do you consider that Photography (one of the assumed means) would suffice for the purpose?

(4.) Do you consider that the class of observations (included in your answer to my question 2) are such as can be efficiently made in an observatory maintained by the State, or that any of them would be better left to the zeal of volunteer astronomers?

May I be permitted to use your answers to the above questions should I wish to do so?

[Addressed to M. Faye only.]

(5.) Do you consider that it would be advantageous to carry on Physico-Astronomical researches on an extensive scale, and Meridional observations in one and the same observatory, under a single director?

Glasgow College,
DEAR COL. STRANGE, 19th June 1872.

I REGRET very much not to have been able sooner to write to you, according to your request, stating my views regarding the requirements for an observatory of Astronomical Physics. I fear very much that what I now write may come too late, but still I do not wish to lose the chance.

The subject of investigation in any observatory for Astronomical Physics is so very different from that for which the great Astronomical observatories at present existing were founded, that I believe generally it would not be good economy of resources to attempt to adapt the old observatories to the new investigations. The instruments adapted for accurately determining the positions of the heavenly bodies, which constitute the most important part of the great observatories hitherto established, are scarcely adapted to give any contribution towards Astronomical Physics. New instruments designed for the work of the spectroscope, and new buildings to contain them, are necessary. A chemical laboratory, and an extensive system of galvanic batteries and electro-magnetic apparatus are required for the new kind of Astronomical observatory. I doubt very much whether one man could act effectively as executive chief of an observatory of Astronomical Physics, and at the same time of an observatory of the old kind.

I remain, &c.,
Col. Strange. WILLIAM THOMSON.

Owens College, Manchester,
DEAR SIR, May [illegible], 1872.

I HAVE received your letter of 28th inst., in which you ask for my opinion on certain points connected with Astronomical Physics. In reply to your first question, I cannot help thinking that a study of the solar constitution is likely to throw light on the subjects of Terrestrial Physics, such as Meteorology and Magnetism. My reasons are:—

(1.) That I consider the *fact* of a connexion between sun spot activity and disturbances of the earth's magnetism to be very well proved, although we are ignorant of the *nature* of the connexion.

(2.) The recent researches of Mr. Baxendell, Mr. Stone, Professor C. P. Smyth, and others, render it extremely probable that there is likewise a connexion between the period of solar activity and the meteorology of our globe.

(3.) The recent researches of Messrs. Warren De La Rue, Stewart, and Loewy, as well as those of Professor Wolf, render it very probable that there is a connexion between the positions of the chief planets and the behaviour of sun spots.

(4.) The recent observations of Messrs. Browning and others render probable a connexion between the appearance of the planet Jupiter and the state of the solar disc.

I think that all these, taken together, can leave us no little doubt of our duty with regard to solar observations. If we were not only perfectly sure of a connexion, but likewise knew all about the nature of this connexion, the necessity of studying the sun would yet be as strong as that of recording the positions of the various planets with the view of verifying the law of gravitation. But inasmuch as here the nature of the connexion is unknown, it is of imperious necessity to study the sun with the view of accumulating a sufficient number of good observations which may ultimately enable us to determine the nature of this unknown connexion.

We ought to remember how greatly the accurate observations of Tycho Brahe contributed to the generalizations of Kepler, and we ought not to fail in our duty towards Astronomy at this present crisis.

In reply to your second question, I would enumerate the following means of observation of the sun:—

(1.) Eye observations through a telescope.
(2.) Photography.
(3.) Spectroscopic observations.
(4.) Actinic observations.

I ought to add observations of the heating effect of the sun, but I am afraid that we have at present no convenient instrument for such observations.

In reply to your third question, I do not consider Photography sufficient for the purpose. I think that eye observations, more particularly when combined with the spectroscope, are essential to enable us to know what is going on in the sun from minute to minute, and unless we know this, I do not well see that we are ever likely to arrive at a true theory of solar disturbances, or of the connexion between these and the disturbances of the meteorology and magnetism of the earth. Could we ever have ascertained the velocity of the solar currents without the aid of the spectroscope?

As a self-recording instrument for registering the actinic effect of the solar rays has been perfected by Dr. Roscoe, and as it is a point of importance to study the influence of the solar rays upon vegetation, I think that whenever the sun's surface is regularly studied, actinic observations ought, from this cause as well as from their physical importance, to be included among the duties of the observatory.

In reply to your fourth question, believing that a long continued and systematic series of observations is beyond the means of volunteers, I think that the four kinds of observation of the solar surface which I have specified ought to be made in an observatory maintained by the State. Indeed, for some of them more than one observatory would be requisite, for I think it an object of great importance to obtain a daily record not only of the position but of the area of every group of spots which appears on the surface of the sun. But to obtain this more than one observatory would be necessary, for we must be independent of the influence of weather; and to be so we must have stations so distributed that when it rained at one station it might reasonably be expected to be fair at another.

The insufficiency of a single station is shown by the fact that in the observations recently reduced by Messrs. De La Rue, Stewart, and Loewy, owing to blank days a good record of the behaviour of groups with regard to increase and diminution, as they pass across the disc, can only be obtained for half the whole number of spots observed, and even for this half in a more or less imperfect manner.

The insufficiency of private means to continue a long series of such observations is also very well illustrated by the Kew series. It is well known that Dr. Warren De La Rue has undertaken since 1862 the charge of the Kew photo-heliograph, and that the Royal Society have until recently contributed yearly funds from the Government grant for the working of this instrument, but this annual Grant has now expired, and in consequence we are at the present moment without a single station in any favourable part of the earth's surface from which anything approaching to a sufficiently regular production of sun-pictures is likely to proceed.

But what applies to Photography applies equally to other observations. I do not therefore think that it would be desirable that any of the four classes of observations which I have mentioned should be left entirely to the zeal of volunteer astronomers.

We know of what value such zeal has been in opening up new lines of research, but when once this has been accomplished the new country ought to be taken possession of by an organised scientific force.

I therefore think that the study of the sun ought to be systematically conducted in an institution for the purpose working under Government, and connected with a number of stations sufficient to ensure a good record of what takes place on the solar surface, independent of the influence of weather.

It appears to me also that such an institution should have a laboratory as well as a workshop connected with it.

Our object being to detect not merely the chemical constituents, but likewise the temperature, the pressure, and the velocity, and perhaps mass of the solar currents, it is essential to know by means of laboratory experiments how these various influences affect the spectra of terrestrial elements.

In fact, the same individual who observes the sun should also experiment in the laboratory. Most certainly the observations ought *not* to be made by one man in one place, and the experiments by another man in another place.

From my experience at the Kew Observatory, where physical problems were investigated, and experiments made, I think that in addition to a laboratory a skilled workman and a good workshop will prove to be very necessary adjuncts to any wisely-devised physical observatory.

I am, &c.,
B. STEWART.

Lieut.-Col. Strange, F.R.S.

DEAR SIR, Paris, 25th May 1872.

REGRETTING that travel and pressing engagements have prevented me from replying sooner to your letter of May 13, I now proceed to answer your questions.

(1.) That the systematic study of the sun's constitution is likely to throw light on subjects of terrestrial physics, I would unhesitatingly affirm; yet without expressing the belief that the minor meteoric or magnetic variations are dependent on changes taking place in the sun.

(2.) The available means for studying the sun at present known to science are, in my apprehension, in addition to observations made with the eye, solar photography, photometric and calorimetric observations, and spectroscopic observations, combined with laboratory experiments necessary for the interpretation of the latter.

(3.) I do not think that photography alone will suffice for the purpose indicated, since it will give little else than a registration of solar spots, the study of which by means of the spectroscope appears to be also of prime importance.

(4.) I perceive no difficulty in organizing the several classes of observations above mentioned systematically, so as to be efficiently made in an observatory maintained by the State. Similar considerations to those upon which the maintenance of meteorological and magnetical observations is based, would warrant a provision for systematic observation of the sun.

The value of the latter, as of the former classes of observations, largely depends upon their regular continuity, which cannot be expected from the zeal of volunteer observers, who must look for their reward to results of immediate interest. In my judgment it is proper for the State to provide for scientific research in all matters which advance the mental or material interests common to all, while they cannot benefit the individuals who pursue the investigation.

I remain, &c.,
J. E. HILGARD,
Secy. Natl. Acady. Sciences, U.S.A.

Lieut.-Col. A. Strange, &c. &c.

CHER MONSIEUR, Douai, le 25 Juin 1872.

LA LETTRE que vous m'avez fait l'honneur de m'adresser à Paris me parvient aujourd'hui seulement au milieu de l'inspection annuelle dont je suis chargé pour les Lycées et les Facultés des Sciences. C'est vous dire que j'ai à peine le temps de recueillir mes idées pour répondre à vos questions. Veuillez donc excuser le décousu de cette lettre et réclamer pour moi l'indulgence de ceux à qui vous avez l'intention de la communiquer.

1°.

L'étude de la constitution physique du soleil ne me parait pas appelée à répandre de grande lumière sur la Physique Terrestre, c'est-à-dire sur la Météorologie et le Magnétisme. L'action solaire est actuellement caractérisée par une constance bien remarquable, sauf de petites variations accidentelles ou périodiques de peu d'importance. L'étude directe de ces divers sujets de Physique Terrestre suffit amplement. Mais il en est autrement des âges géologiques dont l'histoire me paraît liée intimement à des changements progressifs d'ont on reconnait la possibilité dans l'activité interne du soleil.

Toutefois on ne peut nier que les recherches nouvelles qui ont eu pour but de rattacher certaines périodes dans les phénomènes magnetiques aux phénomènes également périodiques du soleil ne méritent intérêt et considération.

2°.

Les moyens dont nous disposons aujourd'hui pour l'étude du soleil sont au nombre de huit:—

1°. Étude des mouvements de la photosphère par les taches et les facules. (Carrington.)
2°. Étude de la constitution chimique de la photosphère et de la chromosphère. Variations, plus ou moins rapides, de cette constitution. Analyse chimique continuelle de la superficie solaire.
3°. Étude des mouvements de la chromosphère, éruptions, protuberances, etc. Distribution de ces phénomènes selon la latitude.
4°. Étude des variations périodiques de la surface, par les procédés de Schwabe et ceux de l'Observatoire de Kew.
5°. Étude des éclipses totalles, auréole, couronne, etc., au moyen d'expéditions lointaines.
6°. Étude des changements séculaires de l'activité solaire au moyen des données de la géologie.
7°. Étude analogique du soleil au moyen de l'observation des étoiles variables ou nouvelles.
8°. Application de la mécanique moderne à l'étude des mouvements internes qu'on peut supposer dans la masse solaire.

3°.

Le moyen le meilleur d'étudier les mouvements des taches et des facules est incontestablement la photographie. C'est surtout par là qu'on peut espérer de rencontrer des

phénomènes auxquels s'appliqueront tôt ou tard les lois de la mécanique. Mais ce n'est là qu'une face de la question. La spectroscopie n'est par moin indispensable. C'est par elle que la physique et la chimie peuvent s'appliquer aux études solaires aussi bien que la mécanique. Réduire cette étude à la photographie ce serait se condamner à ne voir qu'une face de la question. Je ne veut pas que cette opinion puisse être sérieusement soutenue.

4°.

Il suffit d'envisager l'importance du but des études solaires et la variéte du moyen d'action que la science moderne nous présente pour penser que le moment est venu de confier les études à un ou plusieurs établissements pourvu de grandes ressources, et pouvant fonctionner avec continuité pendant un laps de temps illimité.

Sans doute on devra compter sur le concours puissant des volontaires de la science. Mais le concours se présente toujours avec des restrictions quant aux ressources, à la continuité, et à la durée, lesquelles me paraîssent peu compatibles avec les résultats à obtenir.

5°.

Je suis d'avis que les études doivent être poursuivies dans des établissements spéciaux; que leur introduction dans les observatoires astronomiques serait nuisible à l'astronomie proprement dite, sans pourvoir donner tous les résultats que procurerait une division bien nette du travail. L'expérience que nous en avons en France ne paraît décisive, et c'est là un point qui mérite quelques développement.

On a souvent comparé la marche méthodique et l'immense trésor d'observations accumulées de l'observatoire de Greenwich avec l'histoire plus accidenté, et la fecondité bien moindre, de l'observatoire de Paris, contemporain du 1er. La raison du sucès du 1er se trouve dans la netteté du but posé dans l'origine, et l'étroite adhésion à ce but qui a caractérisé tous les directeurs de Greenwich. À Paris, au contraire, on a mêle à la fois, l'astronomie, la physique céleste, la physique du globe, et la géodésie. Aussi, malgré de beaux travaux et de grands services rendus à la science, l'établissement astronomique de Louis XIV., c'est-il laisse souvent détourner de sa marche. En dehors de ces grands établissements, les observatoires moins importants, tels que celui de Marseille, trouveraient un aliment bien suffisant pour leur activité dans le domaine de l'ancienne astronomie, et dans ses applications si importantes à la géographie, à la navigation, à divers points de physique du globe, de tout temps connexée avec l'astronomie, (marées, géodésie, étude de la pesanteur, etc). L'étude physique de la lune, des principales planèts, des comètes, surtout des étoiles doubles, etc., offre un vaste champ à leur activité.

Il en est autrement des études de photographie et de spectroscopie solaires. Ici la part géométrique, analytique est bien faible, tandis que la partie physique et chimique devient prépondérante. Cela est si vrai que j'entends parfois nos astronomes traiter les hommes qui s'occupent du soleil en étrangers et presque en intrus. Non seulement les élémens d'instruction et d'observation sont différens, mais l'esprit n'est plus le même dans les deux ordres d'investigateurs. Les jeunes gens vont même plus loin; les jeunes astronomes n'ont qu'une médiocre estime pour des savants moins bon mathématiciens, qui ne calculent pas, qui ne s'attachent pas au même degré de précision, etc. etc. Je pourrais citer plus d'un fait singulier à l'appui de ce que je viens de dire. J'en conclus que l'argument de la division du travail n'est pas le seul ici; il y a encore celui du peu de sympathie qui existe entre des classes d'individus voués à des sciences diverses, animée de tendance différentes. Ensorte que même en admettant que des astronomes puissent s'occuper utilement d'études solaires, je n'admets pas que l'on doive confondre dans un même établissement les personnels et les instrumens destinés à deux ordres de travaux si différents. Le moment me semble venu d'opérer une séparation semblable à celle qui ont déja eu lieu à diverses époques antérieures pour des branches de science issues d'un même tronc.

L'Association Spectroscopique Italienne semblerait, de prime abord condamner cette opinion, puisque cette association s'est organisée entre des observatoires astronomiques. Mais je ferai remarquer que les observatoires Italiens ne se sont jamais assigné une tâche bien définie. Je dirai ensuite que les travaux spectroscopiques entreprises par eux avec tant de zèle et de talent tendront de plus-en-plus à les envahir et à les détourner des véritables études astronomiques. En Angleterre, où l'on tient à ce que la science soit complétement representée et cultivée, ces raisons là doivent avoir tout leur poids.

En résumé, sur cette cinquième question, je rappellerai que les hommes supérieurs parmi les astronomes tels que Sir G. Airy, Le Verrier, Adams, Hansen, Delaunay, Villarceau, etc., etc., forment un groupe complètement distinct des hommes supérieurs qui ont promu récemment les études solaires, tels que Kirchhoff, Huggins, Janssen, Lockyer Secchi, etc.

Laissons aux un les grands observatoires astronomiques avec leurs instruments méridiens et leurs équatoriaux; donnons aux autres un ou plusieurs grands laboratoires où la photographie et la spectroscopie recevront de puissants moyens pour les études de physique céleste et surtout solaire.

Quant à mois, l'étude du soleil me paraît être le problème caractèristique de nôtre époque. J'applaudirais de grand cœur si je voyais l'Angleterre se mettre en tête du mouvement et élèver pour cette branche nouvelle de la science des établissements tout nouveaux où seraient réunis, sur un large plan, les ressources mises déjà en œuvre ça et là, dans votre grand pays, par les Carrington, les Huggins, et les N. Lockyer.

Veuillez, cher Monsieur, agréez mes excuses pour cette rédaction précipitée, ainsi que l'assurance de mes sentiments de haute considération.

N. FAYE,
Président de l'Ac. des Sciences,
26, Rue Nicolo-Passy, Paris.

Je serai de retour à Paris le 18 Juillet, peut-être assez à temps pour y profiter de vôtre visite.

Lt. Col. Strange.

Translation

From M. Faye, Pres. Ac. des Sciences, Paris.

DEAR SIR, Douai, 25th June 1872.

THE letter you did me the honor to address to me at Paris has only reached me to-day in the midst of the annual inspection with which I am charged for the Lycées and the Faculties of Science. This will explain to you that I have barely time to collect my ideas in order to answer your questions. Pray, therefore, excuse the incompleteness of this letter, and obtain for me the kind indulgence of those to whom it is your intention to communicate it.

1st. The study of the physical constitution of the sun does not seem to me to throw much light on Terrestrial Physics, that is, on Meteorology and Magnetism. The solar action is certainly characterised by a remarkable constancy, subject to small accidental or periodic variations of small importance. The direct study of these various subjects of Terrestrial Physics amply suffices. But it is otherwise with respect to geological periods, of which the history seems to me intimately connected with the progressive changes of which one recognizes the probability in the internal activity of the sun.

At the same time one cannot deny that the new researches which have aimed at connecting certain periods in magnetic phenomena with solar phenomena, equally periodic, merit interest and consideration.

2nd. The means at present at our disposal for the study of the sun are eight in number.—

(1.) Study of the movements of the photosphere by the spots and faculæ (Carrington.)
(2.) Study of the chemical constitution of the photosphere and the chromosphere. Variations, more or less rapid, of that constitution. Continuous chemical analysis of the solar surface.
(3.) Study of the movements of the chromosphere, eruptions, protuberances, &c. Distribution in latitude of these phenomena.
(4.) Study of the periodic variations of the surface by the methods of Schwabe and of Kew Observatory.
(5.) Study of total eclipses, the aureola, corona, &c., by means of distant expeditions
(6.) Study of secular changes in the solar activity by means of geological data.
(7.) Analogical study of the sun by means of observations on variable and new stars.
(8.) Application of modern mechanics to the study of internal movements which may be supposed to take place in the solar mass.

3rd. The best means of studying the movements of the spots and faculæ is undeniably Photography. It is above all in that direction that we may hope to meet with phenomena to which, sooner or later, the laws of mechanics will be applicable. But this is only one aspect of the question. Spectroscopy is not less indispensable. It is by this that Physics and Chemistry can be applied to solar researches as well as mechanics. To confine this study to Photography would be to condemn ourselves to the contemplation of only one aspect of the question. I do not think that this opinion can be seriously entertained.

4th. It is sufficient to contemplate the importance of the object of solar studies, and the variety of the appliances that modern science presents to us, to make us think that the moment has come for confiding these studies to one or several establishments furnished with large resources, and able to work with continuity during an unlimited period of time.

No doubt we ought to reckon on powerful support from scientific volunteers, but that support is always restricted as to resources, continuity, and duration, which seems to me but little compatible with the results sought.

5th. I am of opinion that these studies ought to be pursued in special establishments; that their introduction into astronomical observatories would be injurious to astronomy proper, without being able to give all the results which a well-defined division of labour would secure.

The experience which we have in France seems to me decisive, and this is a point which deserves some development.

We have often compared the methodical march and the immense treasures of observation accumulated at the Observatory of Greenwich with the less marked history and the far inferior productiveness of the Observatory of Paris, contemporary of the former. The reason of the success of the former is to be found in the original definiteness of aim, and the strict adherence to that aim, which has characterized all the directors of Greenwich. At Paris, on the contrary, they have mixed at the same time Astronomy, Celestial Physics, the Physics of the Globe, and Geodesy. Hence, in spite of fine works and great services rendered to science, the astronomical establishment of Louis XIV. has often allowed itself to diverge from its object. Outside these great establishments, less important observatories, such as that of Marseilles, find ample food for their activity in the domain of the ancient astronomy and in its important applications to geography, navigation, and to the various points of the physics of the earth, in all time connected with astronomy (tides, geodesy, gravitation, &c.). The study of lunar physics, of the principal planets, of comets, and above all of double stars, &c., offer a vast field for their activity.

It is different with photographic and spectroscopic solar studies. Here the part of Geometry and Analysis is slight, whilst the part of Physics and Chemistry preponderate. This is so true that I sometimes hear our astronomers treat the men occupied with the sun as strangers and almost intruders. Not only are the elements of instruction and of observation different, but the spirit is not the same in the two orders of investigators. The young men go even further. Young astronomers have but a mediocre esteem for the *savants* of inferior mathematical attainments, who do not calculate, and who are not bound by the same degree of precision, &c., &c. I could cite more than one singular fact in support of what I have said. I conclude from this that the argument of the division of labour is not here the only one; there is also that of the want of sympathy existing between classes of persons devoted to different sciences animated by different tendencies. So that even admitting that astronomers can be usefully employed in solar researches, I do not admit that we should confound in the same establishment the *personelle* and the instruments destined for two orders of work so different. The moment seems to me to have arrived for working out a separation similar to those which have already, in former times, been effected for branches of science issuing from the same trunk.

The Italian Spectroscopic Association seems at first sight to condemn this opinion, as that association has been organized among astronomical observatories; but I would remark that Italian observatories have never assigned to themselves a very definite task. I therefore say that the spectroscopic labours undertaken by them with so much zeal and talent will tend more and more to distract them, and to turn them from true astronomical studies.

In England, where you hold that science should be completely represented and cultivated, the above reasons should have their full weight.

To sum up this fifth question, I would remind you that great men amongst astronomers, such as Sir G. Airy, Le Verrier, Adams, Hansen, De Launay, Villarceau, &c., &c., form a group completely distinct from the great men who have recently promoted solar studies, such as Kirchhoff, Huggins, Janssen, Lockyer, Secchi, &c. Let us leave to the one the great astronomical observatories with their meridional instruments and their equatoreals. Let us give to the other one or several great laboratories where Photography and Spectroscopy may receive powerful means for Celestial and above all Solar Physics.

As for myself, the study of the sun seems to me the characteristic problem of our age. I should rejoice with all my heart if I saw England place herself at the head of this movement, and raise, for this new branch of science, entirely new establishments where there should be united, on a large scale, the resources already in action, here and there in your great country, by the Carringtons, the Hugginses, and the N. Lockyers.

Accept, dear sir, my apologies for this hasty statement, &c., &c.

N. Faye,
President of the Academy of Sciences,
Lt. Col. Strange. 26, Rue Nicolo-Passy, Paris

Communication from Professor Cayley, F.R.S., President of the Royal Astronomical Society of London.

Sir, Cambridge, July 2nd, 1872.

As President of the Royal Astronomical Society, I write to request that you will bring before your Commission the following Resolution, passed at a Council Meeting of the Society, held the 28th June.

In answer to your letter of the 26th June, I beg to say that I do not wish to offer any evidence to the Commission.

I have, &c.
A. Cayley.

J. N. Lockyer, Esq., F.R.S., &c.,
Secretary to the Royal Commission
on Scientific Instruction, &c.

Copy of the Resolution.

1. That the President be authorised, on behalf of the Council and Fellows of the Royal Astronomical Society, to bring before the Royal Commissioners on Scientific Instruction and on the Advancement of Science, now sitting, the importance of further aid being afforded to the Cultivation of the Physics of Astronomy.

2. The Council think such aid would be most effectually given by increased assistance, where needed, to existing Public Observatories, in the direction recommended by the Heads of those Observatories, especially that at the Cape of Good Hope, and by the Establishment of a new Observatory on the Highlands of India, or in some other part of the British Dominions where the climate is favourable for the use of large instruments.

3. The Council do not recommend the Establishment of an independent Government Observatory for the Cultivation of Astronomical Physics in England, especially as they have been informed that the Board of Visitors of the Royal Observatory of Greenwich, at their recent meeting, recommended the taking of photographic and spectroscopic records of the sun at that Observatory.

APPENDIX VIII. (See Question **10,522**, Vol. II., p. 97.)

Remarks on the History and Position of the (now abolished) Board of Longitude.

By Sir G. B. Airy, K.C.B., Astronomer Royal, formerly Member of the Board.

1. The Board of Longitude was first established in the year 1713 (12th year of Queen Anne) "for finding the longitude," and apparently without any other duty. I am not able to say, without examining the numerous Acts of Parliament relating to it, how it became connected with some other subjects, few, however, in number.

2. The first-named member of the Board is in all cases, I believe, the Lord High Admiral or First Commissioner of the Admiralty. At one of the meetings which I attended, H.R.H. the Duke of Clarence, then Lord High Admiral, presided. But usually the political secretary, Mr. Croker, presided. It was always understood that the Board could not meet except under the presidency of one of the Lords of Admiralty, and thus the Board of Longitude became, in fact, a Committee of the Admiralty. Some of its members complained much of this regulation.

3. Several of the *ex-officio* members, and perhaps others, resided at a distance from London. A London Committee (three persons, I think,) was appointed for *ad interim* business, reporting to the general meetings, held four times in the year. The annual salary to each ordinary member was 100*l*. I believe that the salary to each member of the London Committee was 300*l*.

4. The services which this Board rendered to navigation were very great. I imagine that modern navigation depends in great measure upon them. The establishment of the Nautical Almanac, the Requisite Tables, the "Cambridge Tables" for Lunar Distances, the examination and encouragement to improvement of Mayer's Lunar Theory and Tables, Mason's Lunar Tables, and similar publications, were among their early works.

5. Somewhat later, the improvement of time-keepers came before them. At first, attention seemed to be directed to clocks, and there are at the Royal Observatory some enormous models of clocks proposed for use at sea. But successive improvements of chronometers were made by Harrison, Mudge, Earnshaw, Arnold, and others, all which were examined and tried by the Board, and were rewarded under their powers. I do not doubt that the great steps, which ultimately have led to such marvellous accuracy in chronometers, were due to the efforts of the Board in the last century and the early part of the present century.

6. Instruments for sounding, compasses, and other instruments connected with navigation, though scarcely with longitude, came before them.

7. There are papers of Captain Cook's at the Observatory, but I am unable to say whether they prove that his voyages were under suggestion of the Board.

8. A little before my connexion with the Board, the north-westerly expeditions (in which Mr. Croker took very great interest) had been made, and the Board of Longitude, by special Acts of Parliament, judged of the claims to reward. It was before the Board of Longitude that the evidence (founded on Lunar Distances) was given, which established the claim of Captain Parry's expedition to reward for attaining a certain westerly longitude in high latitude.

9. It appears that the Board recommended grants of money in reward of scientific services or supposed services. Thus, 1,000*l* was awarded to Captain Sabine, for his labours in the pendulum-expedition, of the propriety of which there could be no doubt; 500*l*. was awarded to Professor Barlow for a plate for correcting errors of ship's compasses, which was false in theory, and useless in practice; 200*l*. to a chronometer maker named Ulrich, for which nothing was ever received.

10. It was at the instance of the Board of Longitude that the observatory at the Cape of Good Hope was established.

11. It would seem that, by the time when I became member (1826), the demands for the useful services of the Board were exhausted. The matters which came before it were of the most insignificant kind. Once the chronometer maker Ulrich appeared with a model, which it was impossible to examine at the time. Mr. Herschel brought forward a paper on the improvement of the Nautical Almanac (which subsequently was carried out by an *unpaid* committee of the Royal Astronomical Society). I brought forward the subject of improving the Solar Tables of the Nautical Almanac. And I think nothing else was attempted. Both these were stopped by the resistance of Dr. Young, secretary of the Board, who would scarcely consent to any change.

12. There certainly was no use in maintaining the Board any longer. And when, after its dissolution, some members of the Board wished to raise any influence which they might be able to exert for its restoration, Mr. Herschel and myself refused to join with them.

13. The work which the Board was doing in the later (not the latest) period of its existence, has been since that time executed by officers of the Government, or private societies. The questions of north-westerly expeditions, &c., have gone to the Geographical Society, I believe; the repetition of the Cavendish experiment was suggested and carried out at the public expense by the Royal Astronomical Society; important geodetic work has been planned and effected by the officers of the Ordnance Survey: the British Arc of Longitude (Greenwich to Valencia) was planned and executed by me; the experiments on gravity in a deep mine were conducted mainly at my private expense; the proposals for expeditions for the Transit of Venus have been mine; the proposals for Eclipse Expeditions have sometimes originated with others; the attention to chronometers has been exclusively mine; other questions have been referred to committees of the Royal and Royal Astronomical Societies, and perhaps of other bodies.

G. B. AIRY.

1872, May 18.

APPENDIX IX. (See Question **10,689,** Vol. II., p. 108.)

MEMORIAL to the Right Honourable the LORDS COMMISSIONERS of HER MAJESTY'S TREASURY.

The Memorial of the British Association for the Advancement of Science,

Humbly sheweth,—

1. That in the year 1867 the British Association appointed a Committee "for the purpose of promoting the "extension, improvement, and harmonic analysis of tidal "observations." From that time until the present, under committees re-appointed from year to year, the proposed work has been carried on. The mode of procedure adopted, and the results obtained up to the month of August 1871, are fully stated in the accompanying series of printed reports.

2. The primary object of this investigation is the advance of tidal science, but the Committee have uniformly kept in view the practical application of their results to Physical Geography, Meteorology, Coast and Harbour Engineering, and Navigation.

3. A large mass of valuable observations, recorded by self-registering tide-gauges during the last 20 years, having been found available, the Committee have applied themselves, in the first place, to the reduction of these observations, and have deferred the object of promoting observations in other localities until the observations already made have been utilized to the utmost.

4. The work thus undertaken has proved, as was anticipated, one of labour. The calculations have been performed, under the superintendence of Sir William Thomson, by skilled calculators recommended by the Nautical Almanac Office. The funds required to pay the calculators, and to print and prepare tables, forms for calculation, &c., to the amount of 600*l*., have been granted by the British Association in four successive annual allowances of 100*l*. each, and a sum of 200*l*. voted at the last meeting. The last grant barely sufficed for the work actually in hand, and to secure the continuance of the investigation additional funds are necessary. The Council of the British Association, therefore, directed the Tidal Committee to make an application to the Government for assistance, the amount at present asked for being limited to 150*l*.

5. It seemed to the Council that after the Association had done so much in the way of actual expenditure of time by the members of its Committee, and had given such a large contribution from its very limited funds, enough had been done to show the object to be one for which assistance may reasonably be expected from Government. On representations made by Colonel Walker, Director of the Trigonometrical Survey of India, the Indian Government has already granted the means of defraying the expense of making tidal observations in India, and applying to them the methods of reduction devised by the Committee of the British Association. The Council hope, therefore, that the Government of this country may be similarly disposed to assist in a matter of national importance.

(Signed) WILLIAM THOMSON,
President of the British Association.

May 21, 1872.

SIR, Treasury Chambers, June 3, 1872.

THE Chancellor of the Exchequer has referred to the Lords Commissioners of Her Majesty's Treasury the Memorial of the British Association for the Advancement of Science, forwarded to him with your letter of the 21st ultimo, praying for Government assistance in connexion with Tidal Observations.

I am to state that their Lordships have given their anxious attention to the Memorial, and that they are fully sensible of the interesting nature of such investigations, but that they feel that if they acceded to this request it would be impossible to refuse to contribute towards the numerous other objects which men of eminence may desire to treat scientifically.

Their Lordships must, therefore, though with regret, decline to make a promise of assistance towards the present object out of public funds.

I am, &c.
(Signed) WILLIAM LAW.

Sir W. Thomson, Athenæum Club.

APPENDIX X.

COMMUNICATIONS from GEORGE GORE, Esq., F.R.S., Edgbaston, Birmingham. [See pp. 115–120, Vol. II.]

On the ADVANCEMENT of SCIENCE.

Science may be advanced—1st, by encouraging original research, and 2nd, by encouraging scientific instruction.

The means of advancing science may be divided into two, viz., 1st, by encouraging original scientific research, and 2nd, by encouraging scientific instruction; and as original research is the great source of accurate scientific knowledge, and therefore also of instruction in science, I will speak of it first.

Original scientific research the great fountain head of industry, and an essential element of national greatness.

Original scientific investigation is the great fountain-head of industry, and is an essential element of national progress and greatness: discoveries form the basis of inventions, inventions produce improved arts and manufactures, and improved arts and manufactures lead to increase of employment and to national progress and prosperity. It might be easily shown that in this way scientific research has already resulted in the employment of whole armies of workmen, and in the expenditure of a fabulous amount of money in railways, telegraphs, cotton-machinery, chemical manufactures, gasworks, electro-plating, photography, &c., in this country. This nation largely subsists on the results of scientific knowledge discovered by the labours of unpaid scientific investigators. A large proportion of our national greatness is essentially due to those scientific men who discovered electricity, and its modes of action, and to those who applied our great stores of coal to useful purposes in steam-engines, machinery, gas-lighting, and a multitude of physical and chemical processes. The future success of this nation is dependent upon original scientific research to a degree of which persons in general have but little conception. Hundreds of millions of pounds are being expended in covering the earth with telegraphs, and thousands of millions in covering it with railways, and England has a share in this immense expenditure and construction; and if such enormous results are being produced by only the beginnings of science, what may be expected from its future developments, especially if aided by systematic encouragement?

Original research an unlimited source of improvements in arts and manufactures.

The capability of developing increased commerce by means of scientific research is practically unlimited, because scientific discovery is quite in its infancy, and we are at present only on the very threshold of a knowledge of the forces of nature and of the constitution of material substances. The magnitude of the practical results already obtained by means of it is so great as to fully justify a large degree of encouragement of original research.

There is at present absolutely no provision for the support of scientific investigators.

Original scientific research is *national* work.

At the present time there is in this country no recognised payment for the labours of scientific discovery, and absolutely no provision for the support of men who investigate science. The extension of physical and chemical knowledge by means of original research is *national* work, it benefits the nation but does not pay the investigator. The results of original research are generally unsaleable, because, instead of benefitting a single manufacturer only, they benefit the whole community. At present, original scientific researches are generally made by teachers of science, who expend all they can possibly spare of their scanty incomes in making experiments and observations, and lead lives of self-denying sacrifice in the labour. The very limited means of such men is a serious loss to the nation by greatly retarding the advancement of science, and consequently also of national progress in arts, manufactures, and civilisation. Whilst a multitude of other deserving objects are understood and aided either by the public or the State, original research stands almost alone in receiving scarcely any encouragement. Such neglect will greatly retard the future extension of our trade, and, combined with other causes, has already produced a marked effect in gradually transferring portions of our manufactures to more scientific nations.

It is a duty of the State to encourage scientific research.

How this may be effected.

From the immense value of scientific research to the nation, and its utter hopelessness as a means of living to the investigator, it may, I think, be fairly concluded that it is a duty of the State to provide the chief conditions for its encouragement. With regard to its advancement in the provinces, I beg leave to propose that our Government should aid the leading scientific institutions of the chief manufacturing towns by supplying them with funds for such research, making it a condition that the locality should also provide a certain sum. If a moderate annual grant or payment of money for such a purpose were made to each professor of physics and chemistry in those institutions, and if it were made a condition of the appointment that such research should be made, scientific discovery would be promoted, a more competent class of teachers of science than many of the present ones would be produced, and the expenditure would be highly profitable to the nation. The Government would thereby also remove a great hardship from a class of men who are a great honour to the nation, and afford them an opportunity of being paid for their labour. In such cases each investigator should be at liberty to choose his own subject of research. The most competent and impartial body to determine the deserving character of the recipients, and to distribute the fund, would, I consider, be the Council of the Royal Society. I beg leave also to state that I have made various scientific investigations, the results of which are published in the Transactions of the Royal Society, and have received grants of money in aid thereof from the small sum entrusted by our Government annually to the council of that society; and those grants have been of great service in assisting me to defray the cost of the experiments, and I could not have made the investigations without them, but in each case the experiments have cost me a much larger sum than the amount of the grant, and I have received no payment for my time or labour. A large proportion of the money for defraying the cost of these experiments was obtained by means of private teaching, and saved by a rigid economy.

It is considered by those acquainted with the inner working of our old universities, that numerous fellowships and advantages are conferred upon comparatively unworthy recipients in other subjects, which might, with great benefit to the nation, be devoted to the encouragement of physical and chemical science; and I beg leave to suggest this second plan for consideration as a means of advancement of scientific research, or of scientific education.

Scientific discovery the source of scientific knowledge, and the basis of scientific instruction.

Scientific discovery is not only the great fountain-head of industry, but also of accurate scientific knowledge, and is consequently the basis of nearly all scientific instruction. The vast amount of knowledge contained in scientific books was obtained by means of original research, at an immense expenditure of thought and time, and a considerable amount of money, under great disadvantages, and at great self-sacrifice.

General neglect of science largely due to the great preponderance of encouragement of other subjects in our universities.

Discoveries not the results of happy accidents, but of arduous and prolonged labour.

The general ignorance and great neglect of science in this country, both by our Government and by the upper classes, who have the power to encourage and assist it, is, I consider, very largely due to the great preponderance of encouragement given to other subjects in our Universities and large schools. Original scientific research is a subject quite outside the experience and understanding of persons in general, and that is doubtless the chief reason why it has not in our Universities been endowed and encouraged like other subjects, the benefits of which are more generally understood. Nearly all persons look upon scientific discoveries as sudden happy accidents and fortunate ideas, which when once found are quickly developed, and do not look upon them in their true aspect, viz., as slowly developed results of life-long labours of the greatest difficulty, and of exertions of the very highest intellectual power, expended in the gradual extrication of truth out of extreme complexity of error.

Entire absence of aid to scientific research in Birmingham.

In Birmingham the aid afforded to original research is absolutely none. Notwithstanding the greatest trades of the town are essentially results of original scientific discovery, none of the wealthy manufacturers or large landholders of the locality have yet been sufficiently enlightened and liberal to promote the means of future progress by endowing a chair of chemistry or physics with a fund for original research; that which has been the duty of all has been attended to by none. Our large manufacturers and men of business have accepted and employed the advantages of science in an endless number of ways in their occupations, and have thereby acquired great wealth; but they have not sufficiently encouraged scientific education, and have entirely neglected to aid original research. How can we expect to obtain new arts and manufactures, or improvements in old ones, if new discoveries are not made in the properties of matter and its forces?

Birmingham manufactures are largely the results of scientific research.

The largest manufactures of this town have essentially resulted from scientific research. Without the discovery of Voltaic and Magneto electricity, the immense production of telegraph wire, and the extensive trades of electro-plating, and electro-deposited copper statuary, would never have sprung up, and the production of galvanic batteries, telegraphic instruments, and cyanide of potassium would not have existed. Without the discovery of nickel we should have had no nickel refineries nor german-silver manufactories. "The number of persons employed in the "nickel and german-silver manufactures in Birmingham "is 7,000." The discovery of phosphorus has also led to the production of a large amount of that substance in this district. The researches of Dr. Matthiessen on the influence of arsenic and other substances upon the electric conductivity of copper has essentially influenced the manufacture of telegraph wire, and measurements of the conductivity of such wire are made in the wire manufactories by means of the methods devised by scientific discoverers. Many other instances might be mentioned in which Birmingham has derived great benefit from scientific research, but it is needless to multiply them.

But little original science in Birmingham, although much might be done.

But little original scientific research is carried on in this town; no original discoveries proceed from the chairs of science here, and men of money would be thereby discouraged from endowing such chairs with funds for defraying the expenses of original research, even if they were so disposed. Numerous important subjects of scientific investigation, capable of yielding valuable results, bearing upon the trades of the town, exist in all directions. Researches in electricity and in inorganic chemistry, particularly the metals and their compounds, would probably lead, as they have done before, to improvements in local manufactures, and thus lay the foundation of future commercial prosperity.

With regard to the advancement of science by encouraging scientific instruction much might be said, but I will limit myself to a few points. That a knowledge of physics and chemistry should form a part of the intellectual training of all intelligent men is manifest when we consider the effects it has upon the human mind.

Mental effects of scientific instruction.

The effects are: to make the mind powerful and accurate in observation, thought, and expression, in all that relates to the physical and chemical phenomena of the universe. Without a knowledge of science we are liable to grave mistakes and accidents, when dealing with the substances or forces of nature, or when drawing conclusions respecting them, and the most common intellectual defect of the better educated part of this nation is deficiency of judgment and reasoning power in such subjects.

Natural science is as powerful a means of developing the mind as is the study of the classical languages; it is evident, therefore, that those who have the direction of large educational establishments, should be learned in the one subject as well as in the other, otherwise they will probably entertain a prejudice against the study of the subject with which they are least acquainted.

Necessity of the heads of schools being scientific.

It is as inappropriate for unscientific persons to have the direction of scientific instruction (as is now frequently the case) as it would be for persons ignorant of classics to direct classical education; and it cannot reasonably be expected that the scientific education of this country will acquire its proper position whilst so many head masters of our schools are comparatively ignorant of science. Misdirected superintendence is worse than none. The head masters should either be scientific, or the scientific departments of the schools should be under the management of competent scientific men.

Insufficient recognition of science in schools.

Even where the teaching of science has been introduced into some of our large schools, it is still in some cases treated as a subject of quite a secondary degree of importance, and is not accorded the degree of respect which is paid to classics and other subjects; in some cases it is relegated to the holiday portion of the week, and is sacrificed to cricket and other less important pursuits; in other instances the teaching is only occasional, and the proportion of boys taught is very small. In many instances the teachers are gentlemen entirely inexperienced in scientific research, and in some instances they have also had but little experience in making experiments before commencing to teach. In some cases the name of the scientific teacher is not published in the school list with the names of the other masters, and thus science is degraded, and the teacher of it is prevented from obtaining the full credit of his successful teaching. In some cases also comparatively inexperienced scientific examiners are appointed to examine the pupils of the class of scientific pupils; and in other instances a classical examiner from a university includes in his examinations the subjects of physics (including light, heat, magnetism, and electricity), Shakespeare, mathematics, English history, chemistry, and the French and German languages. In some cases also the head master claims the custody and use of scientific apparatus, in the use of which he is inexperienced.

In some of our large schools the head masters still entertain the opinion that only men who have been educated at the old universities are competent to teach science, and have carried this antiquated idea so far as to encourage the teaching of scientific subjects by university men comparatively inexperienced in science, and to discourage such instruction by scientific teachers of established repute.

State of scientific instruction in King Edward's Grammar School, Birmingham.

In the Free Grammar School of Birmingham (the income of which is about 13,000*l.* a year) there are nearly 600 pupils; of this number, 20 are taught the subject of chemical physics by me, in one lesson each week, occupying two hours, and 20 more boys receive a lesson in chemistry of equal length from me weekly; in addition to these lessons, about 20 younger boys receive a lesson of one hour's duration weekly, from one of the assistant classical masters, in the subjects of chemical physics and chemistry, before they enter my classes. All these lessons are given in the half-holidays, and the instruction in my classes is not unfrequently interrupted by the boys being absent at cricket. The subject of science is optional to the boys. I was appointed by the governors of the school, in accordance with the statutes, to teach these subjects in the year 186[illegible], and have continually taught in the school since that time, and my name has not been placed on the list of masters of the school. The head master has taken the custody and power to use the apparatus with which I teach. At the Proprietary School, Birmingham, there are at present about 110 pupils; of that number more than 60 receive instruction from me in chemical physics and chemistry; four lessons a week are given in those subjects in the regular school hours.

The form of scientific instruction must be the same for all learners.

The form in which scientific knowledge should be imparted, must, from the very constitution of knowledge, be substantially the same for all learners. Science cannot be readily taught in small detached fragments, applicable to single particular trades, it requires to be taught systematically; students must first learn the basis of science without much regard to its practical applications, and afterwards learn the uses of science in the arts. Actual experience in the technical applications of science must be confined to "trade schools" and workshops, or to the latter alone.

The sciences should be taught in a certain order.

The different branches of knowledge are so related to each other that they can only be effectually taught in a certain order; to us a knowledge of our language precedes, in point of time, all other subjects; physiology cannot be effectually learned by a pupil who is ignorant of chemistry; chemistry cannot be effectually imparted to a pupil who is ignorant of physics. It is beyond the power of man to alter these great natural relations of knowledge to each other, and to the human mind.

Science should be taught—1st, on account of its intellectual value, and 2nd, on account of its technical uses.

Science should be taught primarily on account of its intellectual value, and secondarily because of its use in technical operations. Although it is often learned with the primary view of personal emolument, it should not be taught wholly or chiefly because it will enable the learner to make money, nor even solely because of its highest and noblest result, but rather because of the whole of its good results combined. That would be a comparatively inefficient and imperfect mode of teaching which would not place scientific knowledge before the minds of the pupils in such a form that *every* proper motive in a pupil's breast may act as a stimulus to his learning. The highest motives cannot be set before the pupils for their selection, for however high their object may be they will not fully attain it. The highest motives have also the greatest sustaining power, and if carried out to the end yield the greatest amount of success.

Objects of teaching science.

The chief objects of teaching science should be to impart a love of scientific knowledge, to educate the senses, to train the mind to habits of careful, reliable, and exact observation of material phenomena; to exercise the intellectual faculties and judgment, in reasoning on those phenomena, their causes, operations, and effects; and to impart a knowledge of the principles and facts of science, of their varied manifestations in the material universe, and their applications in the arts, manufactures, and occupations, especially in those of the locality of the school.

Method of teaching science.

The method of teaching science most effectually to a number of students at once is by means of a combination of lectures and lessons; combining both methods at each attendance of the class, by explaining the subject generally to all the pupils, and examining each student individually, also affording opportunities to each pupil in succession to examine particular substances or phenomena. The tutorial portion of such instruction is the most effective, but its extent necessarily diminishes as the number of pupils in the class increases.

Scientific habits best imparted by a teacher accustomed to original research.

Habits of careful, reliable, and exact observation of physical and chemical phenomena, can only be imparted by a more or less prolonged series of lessons illustrated as freely as convenient by suitable experiments, processes, apparatus, models, drawings, diagrams, and the use of the black board. Such habits are best imparted by a fluent teacher accustomed to original scientific research. A teacher who only repeats the experiments of others, sees only the way in which the experiment, under the exact conditions stated, will succeed, and does not adequately realize the numerous ways in which, through slight unavoidable variations in the conditions, it frequently fails, or produces unexpected results; with every experiment, where there is one way of succeeding, there are always many ways of failing. Descriptions in books usually state only the ways of succeeding, and omit to enumerate the numerous interferences and causes of failure, because of its making the description tedious.

Pupils should visit manufactories.

In addition to seeing experiments, it is a great advantage to pupils to have an opportunity of occasionally visiting large manufactories, in company with their teacher, and seeing in operation the principles of physics and chemistry on a large scale.

Science cannot be perfectly taught without the aid of experiments.

The sciences of physics and chemistry can be but very imperfectly taught by a teacher who has acquired his knowledge by reading only, however extensive that knowledge may be. They do not consist, like some subjects, of book knowledge alone, and the plan I have known employed by some university teachers, of telling the pupils to imagine the apparatus and phenomena, is extremely imperfect and ineffective.

A scientific teacher should be wholly occupied in science.

Those sciences also cannot be effectually taught by any person whose time is not wholly devoted to them, because they have become so large that a man's whole lifetime is insufficient to learn them completely. The experimental sciences in general, are not subjects which a confident man, with ready memory and fluent speech, can read to-day and teach to-morrow; they are essentially subjects of care and exactitude, requiring long experience, and the teaching of them is especially unsuccessful when attempted by persons untrained in experiments.

He should be thoroughly disciplined in making experiments and in original scientific research.

A teacher of science should be accurately and fully acquainted with his subject, be able to impart his knowledge readily and clearly, be thoroughly disciplined in experimental manipulation and in original scientific research. If he has not had long and early experience in making experiments, he cannot make them with a sufficient degree of success; and if he has not had considerable experience in original research, his observations and statements are not sufficiently reliable, and he cannot reason correctly on scientific matters.

Original research imparts the most perfect scientific discipline.

Such research is a branch of practical logic, and is the only means by which the teacher can obtain the most perfect scientific discipline. In it he has to continually detect fallacies; to sift a whole host of errors in order to discover a single truth; to exclude numerous interferences in order to obtain a correct and pure result. A teacher who has not had such experience cannot readily detect fallacies or properly estimate the value of a scientific statement or result, and in many cases the detection of fallacy is even more important than the discovery of truth. Not being sufficiently aware by experience of the extent to which interferences operate, he does not sufficiently verify his results; he is apt also to misinterpret them, and to consider he has demonstrated a statement when he has only apparently proved it; for instance, he thinks he has detected arsenic, when he has only found a something which looks like it.

We have no institutions in which such discipline is to be obtained.

Notwithstanding the great value of experience in original experimental investigation as discipline to the teacher of science, it has been extremely neglected in this country, and we possess no colleges or other establishments in which such experience is systematically provided, or in which it is even assisted. All those who wish to acquire such discipline have to make great sacrifices for its attainment, and the result is that a great many of our scientific teachers do not acquire it at all, and are very inaccurate and unreliable.

Many of our teachers of science are comparatively unqualified.

The recent sudden demand for some indefinitely understood scientific education has produced an additional supply of comparatively unqualified teachers, and those appointed in some of our large schools have had only a book knowledge of the subject, but little experience in making experiments, much less acquaintance with the relations of science to arts and manufactures, and entirely without experience in original research. Some also are university men who have received only a few courses of lessons in science before undertaking important appointments as teachers of science.

Difficulty of obtaining good teachers. How it may be overcome.

The difficulty of obtaining a sufficient number of highly-qualified scientific teachers under present circumstances is very manifest, but if science were properly encouraged in this country, the case would be different; many young men possessed of natural scientific ability, who are now obliged to abandon the pursuit of science for want of proper remuneration, would be glad to devote themselves to teaching and to original research, and thus a supply of properly-qualified teachers would be obtained. Several instances have occurred in my own experience of young men of promising scientific ability being driven out of the pursuit of science through want of remuneration.

Causes of failure of scientific institutions

In some cases scientific institutions have largely failed in their objects, because good teaching power has been sacrificed to minor considerations. Some also have largely failed in an educational effect, because they have devoted their attention relatively too much to providing a supply of popular lectures, instead of providing accurate, thorough, and systematic teaching. At the present time also some of the scientific professorships in such institutions are held by men who pursue science solely as a means of living, and make no original investigations; but if the suggestion already made in these pages were adopted, such appointments would be held only by men who pursue science primarily from a love of the subject, and the cause of scientific education would thus be promoted.

Education in this country largely sacrificed to the passing of examinations and gaining of honours.

In this country commercial energy is great, the desire for gain largely swallows up the desire for knowledge, both boys and men wish to see how a knowledge of science will enable them *at once* to get honour or money. In consequence of this desire, education in this country is largely sacrificed to the passing of examinations and gaining of honours; instead of the whole of a class being well instructed, a portion is being comparatively neglected, whilst the other portion is being prepared for examination. Instead of inculcating as the dominant idea, the more honourable and lasting motive of a desire to become good and useful men by means of learning, the lower motive of a desire for gain is made too prominent, and the moral standard of the pupils is thereby lowered. Students are led to think that their success in life depends more upon passing certain examinations than in acquiring a permanent possession of useful knowledge. The greatest effects education can accomplish, are to produce a fully-instructed and well-balanced mind, and to impart to the pupil a love of knowledge and of self-improvement which shall last as long as he lives. No doubt with most persons prizes are strong inducements to labour, but when a desire for gain in the shape of honours and rewards is made the *ruling* motive, the desire for knowledge ceases to exist as soon as the reward is attained. We should adopt far more than we do the plan pursued in Germany; the university system there, "is to encourage a love of study; and the professors, "very unlike our college tutors, are constantly warning "their pupils against studies pursued with a view to examinations and posts."

We should more freely adopt the plan pursued in Germany.

Reasons why science progresses faster in Prussia than in this country.

One great reason why science is progressing faster in Prussia than in this country, is, I consider, the higher dominant motive with which it is studied; and another great reason is the encouragement given to science by the State by the erection of the large Government laboratories of Berlin and other places. On inspecting those institutions, I was surprised by their magnitude and completeness.

Degrees of remuneration obtained for scientific knowledge in this country.

In reference to the remuneration obtained for scientific knowledge in this country, it may be remarked that the occupation of giving scientific aid and evidence in large cases of legal trial, and also making experiments and suggestions in manufacturing and other works of large magnitude, pays the best, and is profitable. The occupation of giving professional training in scientific arts, and giving advice and courses of lessons to manufacturers on the science of their trades, and also making ordinary chemical analyses is less remunerative. The employment of teaching theoretical science in schools and other institutions, yields the lowest remuneration, and badly requires aid and encouragement.

Scientific institutions for supplying the higher kinds of instruction cannot be self-supporting

It is well known also that institutions for affording the higher kinds of scientific instruction cannot be made self-supporting, and are much in want of endowments, and the managers of them are driven by this cause to seek an increase of funds by resorting to popular and sensational lectures and other attractions, instead of devoting the institutions more completely to systematic and thorough teaching.

Reason for this.

The chief reason why ordinary scientific instruction is not remunerative, and why scientific institutions are not self-supporting is, the prospect of pecuniary benefit to the learner is not sufficiently immediate to satisfy his desire for gain.

The higher scientific instruction a fit subject for State aid.

From the immense importance of a more general diffusion of the higher branches of scientific knowledge in this country, and from the impossibility of making such instruction remunerative to the teachers or to the institutions supplying it, it is, I consider, a fit subject for State aid and encouragement, second only to that of original scientific research.

How such instruction may be aided by the State.

With regard to the encouragement of such instruction, I beg leave to propose that Government grants such as are now made to the old universities of England and Scotland and the Queen's colleges in Ireland, be made to modern scientific educational institutions in all the great provincial centres of industry, and that where such institutions do not already exist in those centres, colleges of science be established, and be supported partly by Government grants and partly by local effort.

Birmingham, July 16th, 1870. GEORGE GORE.

FURTHER COMMUNICATION on the ADVANCEMENT of SCIENCE.

I have been wholly engaged during many years in teaching the sciences of chemical physics and chemistry in schools; in giving scientific advice in those subjects to manufacturers and others, in making chemical analyses and scientific investigations for the purposes of trade and manufacture; and in making original scientific researches which have been published by the Royal Society and in scientific periodicals.

Having been thus occupied, my attention has been much drawn to the state of those sciences in this country, and especially to the subject of the advancement of science by means of original experimental research.

My remarks on the present occasion will be chiefly on the advancement of science by means of abstract experimental research, and when I use the word "science" I mean more particularly the sciences of physics and chemistry.

It is my opinion that science is a great and an essential element of national greatness: 1st, because scientific instruction is a powerful means of developing the faculties of observation and reasoning; 2nd, because a knowledge of science is highly necessary in all cases where man has to deal with matter and its forces; and 3rd, because abstract scientific research has already proved itself to be an unlimited source of new industries and of improvements in trades and manufactures. For these reasons also I consider that science ought to be very largely encouraged.

At the present time, in my opinion, science is not at all adequately fostered in this country. Although scientific research is the source of nearly all our scientific knowledge, and the origin of nearly all our great industries, it is so little understood and appreciated that there exists in this country absolutely no payment for such labour, no national provision for the support of scientific investigators, nor even complete reimbursement for their direct pecuniary expenditure. Within the last few years several of our most eminent experimentalists have died, and men equally self-sacrificing in the cause of original research have not risen to [illegible] their place; other eminent scientific chemists who formerly pursued original investigation have abandoned that pursuit and have devoted themselves to more lucrative occupations. Whilst this has been taking place in this country, great scientific institutions have been springing up [illegible] Prussia, at Aix-la-Chapelle, Berlin, Bonn, Carlsruhe, Greifswald, Leipsic, Strasbourg, Stuttgard, and other places, and much original work is being done in them. If we examine a published periodical list of recent scientific investigations, we find that the Germans are making a much greater number of discoveries than ourselves.

There is not, I believe, one person in one million of the population of this country, whose time is wholly devoted to original experimental research. How can we expect to keep pace with foreign nations in manufactures, or in any of the numerous occupations dependent upon science, if we do not make a sufficient number of discoveries in the properties of matter and its forces?

In my opinion science is not sufficiently cared for in this country, chiefly because the members of our governments, the governing bodies of our Universities, and the head-masters of our large schools, have not been educated in science, and have consequently been unable to adequately appreciate the great value of science for educational, manufacturing, mining, agricultural, warlike, nautical, and many other purposes. It is a rarity to find a member of our Government or a principal of a college who has ever made an original scientific research. This general absence of scientific knowledge in the governing classes and the directors of education in this country is, in my opinion, the greatest obstacle that exists to the advancement of science, and is largely due to the state of scientific instruction at our Universities; it is also a fact worthy of most serious consideration, because the evil effects of it are of national magnitude.

To give to gentlemen who are comparatively ignorant of science the power to control State aid to science and to direct scientific education is, in my humble opinion, most illogical, and the most effectual plan that could be devised for obstructing the advancement of science in this country. To give to science its proper position, our rulers and educators must be adequately instructed in it as they are at present in other subjects.

These remarks are not made in a spirit of disparagement or of fault-finding, for I consider it impossible for those gentlemen to acquire a sufficient knowledge of science in addition to all their other subjects. The real explanation of the case, in my opinion, lies in the greatness of knowledge, and the smallness of our minds. The domain of knowledge has become so vast, that no man who attempts to learn all its divisions can acquire more than a very imperfect acquaintance with each. If men possessing a sufficient knowledge of science, as well as of all the other necessary subjects, cannot be found to fill the places of rulers and educators, it is clear that those appointed to such posts should not be entrusted with the power nor burthened with the responsibility of directing subjects they do not understand. This difficulty, in my own opinion, can only be overcome by establishing a scientific department of the State, and appointing scientific men at the head of it, with power and responsibility equal to the national importance of the subject; and by establishing scientific departments in our Universities and large schools, with scientific principals and masters at the head of them.

The advancement of science in this country, in my opinion, depends not only upon the formation of a scientific department of the State, and scientific departments in our Universities and large schools, but also upon imperial encouragement of abstract scientific research. Abstract scientific investigation is, in my opinion, *national* work, 1st, because of its great national value; and 2nd, because nearly the whole of the benefit arising from it is reaped by the nation at large, and but little, if any of it, goes to the investigator; this result arises from the unsaleable nature of abstract knowledge, and cannot be prevented. Being, then, national work in the fullest sense of the words, original scientific investigation should, in my opinion, be encouraged by our governments, and be paid for out of the national exchequer.

From the immense utilities in the form of telegraphs, gas works, chemical works, electro-plating, photography, &c., &c., which have been essentially originated by abstract scientific research, and could have had no existence without it, it is my opinion that scientific research originates its most important practical results, only when it is pursued from a love of knowledge alone, and that the more abstract a scientific investigation is, the more truly national, widespread, and practical are its ultimate results. With regard to the means, therefore, which may be adopted for promoting scientific research in this country, I consider that national laboratories should be erected, in which abstract scientific investigations alone should be carried on, leaving the discoveries which are there made to be converted into inventions and applied in manufactures and trades by inventors and men of commerce. By this plan alone, in my opinion, will the results obtained be the most national and widespread in their character, and be the least capable of being turned to immediate personal profit by individual speculators.

In the laboratories proposed, scientific investigators of repute should be wholly employed upon such researches, be paid for their labours, and be supplied with all the necessary means in their respective sciences, leaving each investigator to choose his own special subjects of research.

As the new knowledge acquired by means of original scientific research is the origin and basis of inventions and patents in general, if all original scientific research were to cease, the more valuable portion of new patents taken out, and also the yearly number of new patents would, I believe, greatly diminish; it appears to me, therefore, that one of the most legitimate sources from which to obtain funds for the purpose of aiding abstract scientific investigation would be the fees received for the granting of patents.

GEORGE GORE.

Birmingham, May 2nd, 1872.

On a National Laboratory for Scientific Research.

One plan for assisting scientific research in this country would be by founding a national State-supported laboratory, in which scientific investigations alone should be carried on, appointing discoverers of the highest repute as permanent salaried officers in it, who would be wholly employed in research, be provided with assistants, and supplied with all the necessary means in their respective sciences.

The sciences I would propose to include in such a scheme, and to which the remarks in this paper more particularly apply, are those of physics and chemistry, not because I consider the building should be devoted to those alone, but because those are subjects to which this plan might be successfully applied, and are the subjects with which I am best acquainted.

Separate laboratories for each science, and separate sets of rooms for each investigator, would be required in the building, in order to keep the researches distinct. The laboratories would require to be of reasonable magnitude, and should be fitted up with all the most improved appliances, and would be much the same in all respects as private laboratories specially erected for physical and chemical research.

Such a building would of course be on a scale of magnitude creditable to the nation, and in some degree commensurate with the national importance of scientific research. The funds necessary for the entire scheme might with propriety be obtained from the fees received by Government for the granting of patents, because the great bulk of our patents are based upon knowledge obtained by original research. The expenditure of the money upon such a State institution would also be highly profitable to the nation.

The number of investigators in such an institution would not be many, because few men of really high repute as discoverers could be had; such men must be born with the gift, and the gift be developed by favourable circumstances. Either two or three chemists and a similar number of investigators in physics might be obtained. I leave others to suggest the number of gentlemen most suitable for other kinds of research.

It is quite practicable to obtain a small number of suitable men by selecting only those of a high character and who have obtained considerable repute as discoverers. The appointment of them might be most suitably made by a Scientific Council of the State, and the country might reasonably depend upon the character and known ability of the investigators for the results.

We know that undue wealth is the most powerful opponent of industry: it would be therefore desirable that whilst the salaries attached to such appointments ought to be sufficient to render the lives of such men free from pecuniary care, if expended with a reasonable degree of economy, they ought not to be so large as to produce idleness. Provision should be made so that if an investigator persistently failed to make or publish his researches without reasonable cause, he should be removed.

The appointment and payment by salary of scientific men in such an institution would probably not lessen their independence, but rather the contrary, because they would be put into a sphere in which they could more fully exercise their highest scientific faculties than they can at present, and they would feel as they do now, that they were public benefactors to a far greater extent than the value of their salaries, and were a means by which science would honour the nation. It may also be remarked that scientific men of repute who carry on original research, have often to refuse profitable engagements in order to do so, and might obtain much more money if they chose to abandon research.

Each investigator should be allowed to choose his own special subjects of research, because every scientific man is the best judge of what he is able to do, and if any restriction at all were placed upon his selection, it should be that he should not examine any subjects which other investigators had already commenced, and that the subjects he selected should lie within the sciences he proposed to investigate. In practice, however, no greater difficulties than occur at present would probably arise on these points, because every investigator of position purposely avoids trespassing on another man's sphere of research, and every discoverer of repute is possessed of so many good subjects of investigation as not to require to do so.

The investigations carried on in such a building should be entirely for the purpose of making discoveries and not at all for effecting inventions. They should be directed only to the discovery of new facts and principles in science, and the decision of purely scientific questions; first, because such research has already proved itself an unlimited source of new industries, has added great wealth and power to the nation, has led to the expenditure of hundreds of millions of pounds in productive labour, and to the employment of whole armies of workmen; and second, because the knowledge so discovered would, when published, not be in a patentable or saleable state, and therefore could not be used by speculators or monopolists for their own individual benefit.

In selecting the subjects of research, and in making the researches themselves, the idea of any *immediate* useful application would have to be avoided; not that the object of the investigations should be to discover useless knowledge (if there is such a thing), quite the reverse, but because the selection of a subject of research with such an idea as the guide, would result in less important discoveries being made. We do not know before an investigation is made, whether the results of it will ultimately prove of little or great utility, but we do know by long experience that the discoveries which have proved of the greatest national value have almost always been obtained by investigations selected and pursued from a pure love of knowledge alone, and in this sense only should the researches be made with a view to practical use.

If the subjects of research were selected with an *immediate* view to utility, and the researches made in that spirit, the new knowledge obtained would be in the form of *inventions*, and immediately upon its publication speculators would gamble for its possession, seize and patent it, or otherwise turn it to their individual profit, because they could thus obtain valuable and marketable possessions at no expense to themselves.

It would not be desirable that any researches for immediately practical purposes connected with the different departments of the Government, such as the chemistry of projectiles, should be carried on in this institution, because such researches are much more conveniently effected in a laboratory immediately connected with the particular department, such as the arsenal, foundry, manufactory, &c., where the results may be more readily compared with what actually occurs in the technical processes, and be more readily carried out on a large scale. In accordance with this view we find that the largest manufacturers in this country, such as the great brewers and others, possess sufficiently perfect laboratories, and sufficiently able chemists, to make the scientific investigations they require.

There are other researches connected with public wants of a temporary kind, required to be made for Royal Commissions, for instance, analyses of water; these also being of an immediately practical character, would not harmonize as well with the labour in an institution established for discovery only, as with a practical department, such as the Board of Health, and therefore would be most appropriately done elsewhere.

There are also occasionally persons of a highly ingenious and scientific habit of mind, who are full of original scientific ideas, and who might wish to use the institution for the purpose of original research; but the ideas of such persons are often very crude, and the persons themselves have had little or no experience in the actual work of discovery, and therefore should not be permitted to do so.

The whole of the results obtained by research in such an institution, should be considered and treated as the property of the nation, and all those worthy of publication should be published without the least reserve; and as the investigators would be salaried officials wholly in the service of the State, they should not be at liberty to patent or sell any of the knowledge obtained, nor enter into any other employment.

It would be necessary in such an institution to appoint such scientific men as would engage to publish their results either periodically or soon after the researches were completed, in order that the nation should not fail to obtain a return for its expenditure; but as there are some scientific men who have an objection to publish their results, if such gentlemen were appointed it would be necessary to associate with them companions in research who would perform that duty: such arrangement as this is often adopted.

If the gentlemen appointed in such an institution were men of the highest scientific repute, the results obtained by their researches would nearly always be valuable, because they would be able to select promising subjects, and would know previously whether the subjects had been already exhausted. No man can tell beforehand what he will discover by original research, otherwise such research would hardly be necessary, but investigations properly conducted can hardly be barren of results, and those which terminate in negative ones are quite the exception, and even negative results often possess considerable value.

The new knowledge obtained by the researches in such an institution would be published either periodically or as the researches were completed, and would be precisely similar in character to that contained in papers now communicated to the Royal Society, and would be at once at the service of compilers of text-books of science to incorporate in those books for the purpose of instruction throughout the kingdom; it would also be at the service of inventors to form a basis of new inventions, but it would require, precisely as such knowledge does now, to be passed through the laborious ordeal of invention before it could be made patentable, saleable, or what is generally termed "practically useful."

Such an institution as is here proposed would be but an extension of the system which has long been in use in the German and French State-supported laboratories. In those buildings the professors have rooms and appliances of all kinds provided for them at national expense, for the purpose of making researches, and receive salaries from the State, and nearly the whole of the difference between those laboratories and the one proposed is, that in the former a portion only of the professors' time is devoted to original research, the remainder being occupied in lecturing, and research is not a matter of duty, whilst in the latter, their time would be wholly occupied in research as official employment.

It may be necessary to state why original research should be paid for by the State. Original research is national work, and should be paid for thus; first, because the ultimate results of it are of immense value to the nation at large; second, because nearly the whole of the benefit goes to the nation, and very little of it to the investigator; and third, because there is at the present time no protection for the immediate products of a discoverer's labour, and absolutely no means for his support.

One of the first duties of a Government is to protect the citizens in the possession of their property, but in the case of discoverers any one can rob them of the immediate fruits of their labours with impunity; any one may take any published discovery without payment, and use it to his own advantage by converting it into a saleable invention.

It is well known that inventors in this country find a difficulty in protecting their properties by means of our patent laws, especially if they are poor and their inventions are valuable or of wide application, and that with few exceptions they have still more difficulty in making their labours profitable; but there would be much greater difficulty in protecting discoveries than in protecting inventions, because the former are generally much more universal in their effects, and would be pirated by a much greater number of persons.

The discovery of a single substance or principle in science has often led to more than 100 patented inventions, and to the establishment of more than 100 manufactories; for instance, the discoveries of gutta-percha, oil of vitriol, india-rubber, the principle of electro-magnetism, &c. Scientific discoveries probably constitute the most productive kind of property that exists.

The immediate products of scientific research are utterly unsaleable, first, because they have not been converted by the process of invention into practical shapes; and second, because there is no legal protection for them: no man will pay for what he may take without payment. The only advantage an investigator gets for his labours is fame, and if he happens to be a professional chemist he can command a higher rate of payment for his services in consequence of his greater repute, but nearly always in science, the greater the ability, labour, and fame of a discoverer, the smaller is his income.

It may be objected that the State should not pay for original research, because years may elapse after the research has been made before the nation will gain the full benefit, but that is not a sufficient reason: many years elapsed after Sir Charles Barry designed the plans of our Houses of Parliament before the houses were practically used, but that did not prevent his being paid for his labour. The only question of importance under this head really is, do the benefits of original research nearly all go to the nation at large, and not to individuals, localities, or isolated communities? and that has already been answered in the affirmative.

The circumstances in this country have, chiefly by the undue influence of wealth, become such that either discoverers must be provided with means of existence, or they must cease to investigate. Some of our ablest investigators have already adopted the latter course, and the remainder will probably follow. Several also of our most eminent discoverers in physics and chemistry have died, and others have not arisen to take their places. The results of this will probably be, that good inventions will become more rare for want of new scientific knowledge, and improvements in arts, manufactures, agriculture, means of defence, and many other important matters will decline, and this country will become more dependent upon other nations, and have to obtain improvements in manufactures at second hand. National superiority can only be maintained by being first in the race.

I will now state why I consider it desirable that the whole of the time and energies of the investigators appointed in the proposed institutions should be devoted to original research instead of being partly occupied in teaching.

First, because the faculty of research is of much greater value to the nation than the faculty of teaching; research creates new knowledge, teaching simply distributes it. The labours of a scientific teacher consist essentially of a series of repetitions of other men's discoveries. If the teacher is also an investigator he finds the occupation of teaching a great advantage, because it compels him to study all parts of his subjects, and in doing so he suggests many new questions for original research. But after a teacher has acquired a thorough knowledge of his subjects, and great experience in his profession, his personal improvement in it becomes less rapid, and his occupation gradually becomes to him a species of intellectual drudgery, in which he is continually going through the same course of lectures and examinations, over and over again. If he is also an investigator, he suggests during his career of teaching a much larger number of important subjects of original research than he can live to investigate, and he finds the occupation of teaching interfere with the more valuable employment of research by depriving him of the necessary time. Faraday at the middle period of his life gradually gave up nearly all his other occupations in order to obtain more time for discovery, and other investigators who have possessed means of living have done the same.

Second, if teaching is also carried on or lectures delivered in the proposed building, then the State laboratories will compete with educational institutions established by private enterprise, and place them at undue disadvantage, but if the laboratories are entirely devoted to original research they will compete with no institution, and will interfere with the pecuniary success of no one, because no person gains a living by means of original research.

And third, it is desirable for the national welfare there should exist in this country some post or employment to which those teachers (and others) who are men of repute in discovery might look forward, as a sphere in which the most important of their scientific faculties might be developed to their fullest extent.

George Gore.

On Plans for encouraging Original Scientific Research.

In addition to the plan of encouraging scientific investigation by means of a State-supported laboratory, with discoverers of repute as permanent salaried officers wholly engaged in research in it, the following plans may be suggested:—1st. Giving State aid, in the form of additional salary for the purposes of research, to the leading teachers of science in the colleges and chief educational institutions of the country; 2nd. Making it a condition at all our Universities, that every student entering for a degree in science should previously make an important original investigation; 3rd. Extending the present system of giving Government grants of money to private investigators; and 4th. Raising funds for research in towns by means of private subscriptions, and applying the money so raised to aid local investigators.

The *first* plan, viz., that of giving State aid in the form of additional salary, for the purposes of original research, to the leading professors and teachers of science in the colleges and chief educational institutions, is a new proposition which has not yet been tried.

In carrying out this plan it would be necessary to assist only those gentlemen who had already made and published a good research, and thereby proved their ability to do so, and who would engage to make research a part of their duty in consideration of the increase of salary. The best teachers are those who have the greatest love for their profession, and those would be chiefly the ones who would find time for original research, and avail themselves of the additional salary.

It would be necessary to provide that in case a recipient of the aid failed to make and publish a reasonable amount of good research, his additional salary should cease; the payment therefore would be substantially based upon results. The money should be wholly employed in researches in pure science, and not in researches made with an *immediate* view to invention or practical use; the knowledge obtained by means of the researches should be entirely national property, and the investigator should not be permitted to sell it or make it the subject of a patent.

The money for this plan might be derived from fees received by Government for the granting of patents,* because the great bulk of our patents are based upon knowledge discovered by means of original scientific research. The selection of suitable recipients, and the administration of the funds, might be entrusted to a scientific Council of the State.

The advantages of this plan of aiding research would be, that it would induce some of our teachers of science to engage in and make researches who have never yet done so; it would cause others who have already made researches to continue their labours; and it would develope a superior class of teachers of science in the colleges, great public schools, and higher scientific educational institutions of the country. Its chief disadvantage would be, that it would require some time to produce an effect, because there are at present very few of those gentlemen who have yet shown the requisite ability to make original researches.

It is well known that all the best teachers of science in this country, Europe, and America, have always been men who devoted a portion of their lives to original research; it is also well known that an original investigator is not the best teacher unless he is sufficiently clever in imparting his knowledge.

It is very desirable that all the higher teachers of science in our institutions should devote a portion of their time to original research; because it would make their information much more trustworthy, and because it would induce the students to feel greater interest in the subject, and more respect for the teacher.

It would make the information of the teacher much more reliable, because a teacher who simply follows the instruction given in scientific books is not sufficiently acquainted with the numerous sources of error in making experiments. Whilst there is usually only one way of succeeding in making a particular experiment, there are always many ways of failing. The books only describe the way to succeed, but say little or nothing of the sources of failure; and if the substances or forces used in an experiment are in the least degree different (as they often are) the experiment fails, and the teacher cannot readily correct or explain it, the pupils then ridicule both the teacher and the subject; whereas, if the teacher has had experience in research he is much better able to predict, correct, and explain the results. The discovery of new knowledge also requires a higher kind of ability than that of imparting it, and students therefore have generally greater respect for a teacher who makes discoveries, and they experience a feeling of wonder and curiosity to know how he made them. It may also be remarked that the special excellence of the German system of scientific instruction consists in the union of teaching and original research.

It may be objected, that original research takes a great deal of time, and the teachers in such institutions would not have the requisite leisure; and that it would be better to have a greater division of labour, keeping one man wholly to teach and another to investigate.

The first of these difficulties might be easily overcome by employing more assistants of higher ability; with regard to the second, we know that the practice of teaching developes the power of research, and our greatest scientific discoverers have mostly been men who originally united the two occupations.

The *second* plan, is to make it a condition at all our Universities, that every student entering for a degree in science should previously make an important original research. The subject of the research might be suggested to the student by his teacher.

This plan is a very important one; it has already worked satisfactorily in the German Universities, and if it could be carried out in this country, it would produce most valuable results. The requirement of such a qualification would have largely the effect of improving the quality and increasing the quantity of scientific instruction throughout the kingdom, because making an original research requires a much greater amount of scientific knowledge, a higher scientific training, and greater manipulative ability than are now possessed by students of science at our Universities; and because nearly all the middle-class schools of this country are occupied in preparing pupils for the great public schools and University colleges, and would be compelled to prepare them in science much more perfectly than they do at present.

The greatest obstacle to the carrying out of this plan is practically the undue wealth possessed by the parents of students and by the authorities of the old Universities. An original scientific research cannot be made without considerable industry, and the greatest opponent of industry is undue wealth. Generally where wealth abounds, ignorance of science much more abounds.

It is well known that this country contains a great many wealthy persons, and that most of their sons are educated at the large public schools and the old Universities. It is also well known that undue wealth largely deprives young men of the motive for study. In consequence of this, many youths leave our great public schools imperfectly instructed, many go to the colleges very ill prepared, and there is no large class of industrious students at our old Universities.

According to the college tutors, the greatest cause of the idleness of such students is parental neglect and the habits of wealthy society. Many parents give their sons too much money, and overlook too readily their idleness; the sons also know their parents are rich, and act accordingly. Wealthy parents of less social rank not unfrequently send their sons to the colleges and large public schools more for the purpose of making acquaintance with the sons of the aristocracy than with the object of learning; they wish their sons to be like other young men, and to spend as much as, or even more than their aristocratic companions. Many young men are also sent to the old Universities, not because they are fit to be students, but because living there is considered respectable, and a necessary part of a young gentleman's course.

Another cause assigned has been that the college authorities have acquiesced in the wishes of the parents, and have not sufficiently excluded idle and incompetent students. Being possessed of wealth (*i.e.*, endowments) they have made the colleges as attractive as possible to wealthy students not possessed of high ability, by offering good fellowships without requiring a high standard of attainments, and have not made the colleges sufficiently accessible to poor industrious students. This complaint has been made more of Oxford than of Cambridge University.

Assuming this plan for aiding research can be introduced into all our Universities, it can only be successfully carried out by making the rewards of scientific research adequate to the ability required to effect it, or equal to those gained by knowledge or attainments in other subjects; and by admitting industrious poor students to the colleges, and rendering the prizes as accessible to them as to the wealthy, and excluding incompetent or idle students whether poor or rich. By these means, science will acquire its just share of respect; idleness will be a disgrace in the presence of diligence, and will become alarmed at the success of industry in obtaining the prizes; good fellowships will cease to be given as rewards of incommensurate ability, and great improvement will be made.

It is clear from these considerations, that as long as the kind and amount of instruction at our old Universities are determined by the undue influence of wealth, the proposed plan of aiding scientific research cannot be satisfactorily carried out.

The *third* plan, viz., the extension of the system of giving Government grants of money to private investigators is well worthy of consideration. The Government grant system has been in use many years, and although the yearly amount of money to be administered is small, very few persons, qualified to make good researches, apply for it, and it is difficult to dispose of the whole. The causes of this are, first and chiefly, any person who accepts the grant becomes a considerable loser; second, there are comparatively few persons in this country qualified to receive it; third, only a small portion of those apply for it; and fourth, its existence has not been very widely known.

The advantages of the present grant system are,—it diminishes the amount of loss suffered by scientific men in making investigations, and thereby encourages a few persons to make researches. Its defects are:—it is a temporary and uncertain assistance, it pays nothing for the skill, time, or labour of the investigator; it allows nothing for the payments to assistants, and only partly pays his expenses out of pocket. Further, "By order of the Council, "all instruments, apparatus, and drawings made or ob-"tained by the aid of the Government grants, shall, after "serving the purpose for which they were procured, and in "the absence of any specific understanding to the contrary, "be delivered into the custody of the Royal Society."

---

* A large sum of money (nearly 600,000*l.*) from this source has now accumulated, and has, I believe, been transferred to the Consolidated Fund.

The same amount of skill, time, and labour, expended in any ordinary profession requiring an equal amount of preparatory education, and less rare ability, would yield an income of 1,000*l* or 2,000*l* a year, but if employed in research with the aid of the Government grant not only produces no income, but leads to an actual pecuniary loss.* Gentlemen who formerly accepted the aid have informed me that they ceased to do so because they found it very expensive. If the grants were increased in amount so as to cover all the money payments, the system would be better, and, if still further increased, so as to pay for the time, skill, and labour of the investigator at a very moderate rate, it would be much better. Some persons have expressed the opinion that a discoverer should be satisfied with the fame of his labour, and receive no other reward, but this view is so illogical I need not here refute it.

The lives of a few solitary discoverers have proved that it is possible for a man, with the aid of the present grant system, to do a considerable amount of research; but that is due to the unusually great perseverance, industry, and self-denial of the man, and but little to the aid of the grants; the great rarity of such men indicates the inefficiency of the system. The fewness of our discoverers is due, in my opinion, not only to the rarity of the combination of natural abilities requisite in the men, but largely also to the want of proper encouragement. Of the few men who have sufficient energy to continue research during a number of years, most are compelled to abandon it just when they are in their prime of ability as discoverers, simply because research prevents them making provision for old age.

No amount of extension of the grant system will, in my opinion, ever make it a perfect means of aiding research, or as effective for that purpose as a State laboratory with permanent salaried investigators; *first*, because there are many important researches which can only be made by means of national resources in a national institution; *second*, because the places in which researches are made by the investigators are often very unsuitable for the purpose; and *third*, because the assistance is temporary and uncertain. The system is at the best but a very imperfect one, quite inadequate to the requirements of the case, altogether disproportionate to the national importance of the subject, and quite unworthy of a great nation.

The *fourth* plan is by raising funds in each large town by means of private subscriptions, and applying the money to aid local investigators.

There are in most large cities a few wealthy persons who perceive to some extent the great value of science, and who would be willing to contribute to such a fund; there are others also, who would readily contribute, if the [illegible] the object were properly explained to them.

The chief argument in favour of this plan is, that it is a great duty of persons to aid original research, because most of them have derived great benefits from it. We know that the benefits produced by scientific knowledge are immense; that it has largely contributed to the [illegible] of our wealth, that many great manufacturers have [illegible], by means of its aid, acquired immense wealth; that our large landholders have had the value of their property greatly increased by the erection of manufactories and [illegible] dwellings upon it, and by the discovery of mines [illegible], and many men have become rich by [illegible] telegraphs, railways, gasworks, steamships, and a multitude of other undertakings, which would not have existed but for original scientific research. It was largely by means of the discoveries of our deposits of coal and iron ore, and the genius of scientific men in applying those discoveries to immediately practical purposes in [illegible] cotton machinery, and a multitude of mechanical, physical, and chemical processes, that our superiority as a manufacturing nation over other countries was developed and maintained, and the country acquired its great riches.

Persons in general, in this country, do not believe in these statements, not because these statements are not true, but because they are little understood. Men will frequently not believe what they cannot understand, even though their very existence depends upon the thing to be understood. Previous to the discovery of oxygen in the air, not being able to see that substance, we did not believe in its existence; so persons in general in this country do not perceive that original scientific research is a great fountain of industry and has been a great source of their riches.

It is a fallacious argument to say that because scientific research, and these benefits are not *immediately* connected, the dependence of our wealth upon science is doubtful. A cause as surely produces its effects, however many events lie between, or however numerous its results may be, provided the connexions are perfect. Motion of one end of a chain produces an effect at the other, although many links intervene, and a single act of the mind will set all a man's muscles in motion.

Next to inventors, who use the new knowledge obtained by research, the manufacturers and capitalists get the *most immediate* pecuniary benefit from science, and their gain is often considerable. The *greatest ultimate* gain, however, is obtained by the great landholders, because theirs' is both large and permanent, whilst that of manufacturers lasts only as long as the industry of the man and his descendants continues; and that of inventors is often small, and lasts only as long as the patent.

There are several objections to the plan of raising funds for research by means of local subscriptions; it would not be equitable, because the benefits of the researches made by means of the money would go, not to the locality alone, but to the entire nation; it would be a comparatively temporary and uncertain expedient; it would not be compulsory, and the contributions to the fund would not be in proportion to the benefit derived from research by the individual subscribers, the class of persons who ought to give the most, viz., the great landholders and others, would, in many cases, be the least able to appreciate the value of such research, and would not assist; and it would be difficult to find bodies of gentlemen in the different localities who would be competent to administer the funds, to judge of the fitness of the applicants, the proper character of the researches made with the money, or to resist the importunities of unworthy claimants. If, however, any wealthy persons chose from philanthropic motives to carry out this plan, or found a local college of scientific research, it would be a noble application of wealth, and there could probably be no serious objections made to their doing so.

General Conclusions.

The plan of aiding research by means of a State laboratory, with discoverers of repute as permanent salaried officers wholly engaged in it, is far superior to all the others, because it possesses a national character, and is much more commensurate with the great public importance of the subject. It would also give a great impetus to science by publicly showing the appreciation of it by our Government, and would remove the national disgrace of the greatest benefactors of this country being robbed of the fruits of their industry, and having no means of existence.

If this plan were supported by means of the patent-fees, it would also enable us to adopt a perfectly natural and proper course, by means of which discoverers would be paid for their labours by the very men (*i.e.*, inventors) who *most immediately* derive benefit from them, and thereby also cause the expense of research to fall upon those who gain the *greatest ultimate* benefit, viz., the nation.

Under present circumstances, an inventor patents an invention, he then sells it to a manufacturer, and includes in his price the cost of the patent; the manufacturer works the invention, and includes in the prices of his goods the money he paid the inventor; and the tradesmen buy the goods from the manufacturer, and sell them to the consumer. If, therefore, the patent fees were expended in supporting a State laboratory, the general consumers, *i.e.*, the nation, would pay through the tradesmen, manufacturer, inventor, and the State, for the national work of original research, and as inventions are patented to supply almost every conceivable want, the greatest consumers would ultimately be thus compelled, without the establishment of any new kind of taxation, to pay for original research somewhat in proportion to the amount of benefit received.

The plan of giving State aid in the form of additional salary to scientific professors and teachers in provincial institutions, might be conveniently carried out in conjunction with that of a State laboratory, and be supported by similar means; it would also produce a supply of investigators for that institution.

---

* [illegible] which is so lost is paid out of that portion of [illegible] income which is expended upon original research.

The plan of making it a condition in all our Universities that every student entering for a degree in science should previously make a valuable original research is a very important one, but it is very doubtful if it could be carried out in our old Universities as long as the kind and amount of instruction in those institutions are as largely determined as they are at present by the influence of wealth; if it could, however, only be made a regulation in *some* of our Universities, it would have a good effect upon the others, and a great improvement would be the result.

The plan of aiding research by extending the present system of Government grants is very inferior to that of a State laboratory; it is also very imperfect, temporary, and uncertain; quite incommensurate with the national importance of research, and altogether unworthy of a great nation.

And the plan of raising funds for research by means of local subscriptions is a comparatively temporary and uncertain expedient, difficult to work, unfair to the localities, and not compulsory; but might be carried out by wealthy persons from motives of philanthropy.

George Gore

APPENDIX XI.

Correspondence of Her Majesty's Commissioners with General Sir Edward Sabine, R.A., K.C.B., as President of the Royal Society, respecting the Government Grant to the Council of the Society in Aid of Scientific Research. [See Vol. II., pp. 139–147.]

From the Secretary of the Royal Commission to Sir Edward Sabine, P.R.S.

(Copy.)

To Sir Edward Sabine, K.C.B.,
President of the Royal Society.

6 Old Palace Yard, S.W.,
July 9, 1870.

Sir,

I am directed by the Duke of Devonshire, the Chairman of the Royal Commission on Scientific Instruction and the Advancement of Science, to inform you that the Royal Commissioners desire to place themselves in communication with the Royal Society in order that they may have the advantage of the experience of the Council of that Society in the administration of the annual grant placed at their disposal by Parliament for the Advancement of Science. I am to add that the Royal Commission would attach great importance to an account of the origin of that grant, together with any important incidents in the progress of the communications of the Royal Society with the Government respecting it, or in the administration of the fund.

Much interest would be felt in the history of any fund or endowment for the special use of the Society, as well as of the accommodation provided in public buildings.

The Royal Commission have reason to believe that the Government have not acted without communication with the Council of the Royal Society in the large outlay incurred in the Magnetic Survey; or in the Department for Meteorological Observations; or in the various Dredging Expeditions, and other similar scientific inquiries, and the Commission would be glad to have such a report, or such evidence on these several matters as might aid them in their deliberations as to the definition of the most useful relations of the Government with the Scientific Associations, and especially with the Royal Society.

I have, &c.
J. Norman Lockyer.

Statement from Sir Edward Sabine addressed to the Royal Commission.

The first two paragraphs of the Secretary's letter refer to the administration of the annual grant of 1,000*l.* placed by Parliament at the disposal of the President and Council of the Royal Society for the promotion of scientific discovery and research.

The grant originated in a letter from Earl Russell (then Lord John Russell) to the Earl of Rosse (then President of the Royal Society), which letter and Lord Rosse's reply were as follow:—

Lord John Russell to the Earl of Rosse.

(Confidential.)

My Lord, Windsor Castle, Oct. 24, 1849.

As there are from time to time scientific discoveries and researches which cost money and assistance the students of science can often but ill afford, I am induced to consult your Lordship, as President of the Royal Society, on the following suggestion.

I propose that at the close of the year the President and Council should point out to the First Lord of the Treasury a limited number of persons to whom the grant of a reward, or of a sum to defray the cost of experiments, might be of essential service. The whole sum which I could recommend the Crown to grant in the present year is 1,000*l.*, nor can I be certain that my successor would follow the same course; but I should wish to learn whether, in your Lordship's opinion and that of your colleagues, the cause of science would be promoted by such grants.

I have, &c.
(Signed) J. Russell.

The Earl of Rosse, K.P.

The Earl of Rosse to Lord John Russell.

The Castle, Parsonstown,
My Lord, November 7, 1849.

I have the honour to acknowledge the receipt of your Lordship's letter of the 24th, in which you do me the honour of requesting my opinion and that of my colleagues relative to a proposition for the advancement of scientific discovery. On the 15th there will be a council of the Royal Society, to which I propose confidentially to submit your Lordship's communication.

In the meantime, speaking merely as an individual, perhaps I may venture to say that in my opinion the judicious employment of grants in the way proposed by your Lordship would very materially promote the advancement of science. There are often details to be worked out before it is possible to employ usefully newly discovered principles. In many of the sciences reductions are required before observations can be made use of. Both in Science and Art, facts technically called constants are the materials of discovery; to determine them accurately is of great importance. Now in all these cases, and in many others, the work to be done is laborious and expensive, and as it adds but little comparatively to the fame of the individual, it especially requires encouragement.

I have, &c.
(Signed) Rosse

On reference to the Minutes of Council of the Royal Society it is seen that these letters were communicated by the Earl of Rosse to the Council on the 22d of November 1849; and that a committee was appointed on the 15th of December following, "to consider and report respecting the application of the proposed grant," of which committee the Lord Chief Baron Pollock was named President.

The report of this committee was presented to the Council on March 7th, 1850. It stated that—

"The Committee had met several times, attended by all its members, who had also availed themselves of the advice and suggestions of other Fellows of the Society, resident and non-resident, whom they had consulted and had finally agreed, unanimously, to the following recommendations, viz.:—

"First and chiefly—That the grant be awarded in aid of private individual scientific investigation.

"Secondly, in aid of the calculation and scientific reduction of masses of accumulated observations.

"Thirdly, in aid of astronomical, meteorological, and other observations which might be assisted by the purchase and employment of new instruments.

"Fourthly, and subordinately to the purposes above named, in aid of such other scientific objects as may from time to time appear to be of sufficient interest, although not coming under any of the foregoing heads."

It was further added—

"Your Committee recommend to the Council that a committee be appointed, consisting of the whole Council for the time being, ex-officio, together with an equal number of Fellows of the Society, chosen by the Council amongst the members most conversant with the business of the Royal Society, or with one or more of the leading departments of science, or officially connected with the principal scientific bodies of the kingdom; such additional members to be named for a period of three years, subject to the annual revision of the Council, and provision being made for filling up the vacancy occasioned by such additional member becoming a member of Council during his term of service on the said committee, should such occur.

"Your Committee consider it very desirable that parties receiving grants for specific purposes should report to the Council from time to time, in such manner as the Council shall deem expedient, on the more or less satisfactory fulfilment of the objects of the grant; and they would suggest that the occasion of the anniversary meeting would afford a fitting opportunity for announcing from the chair the nature of such reports."

In a subsequent Report, in the following May (1850), the Committee added that "in their opinion it is desirable "that in the case of the recommendation of any grant, a "committee of three members should be appointed to "ascertain the proper application of the funds."

The subjoined statements show the appropriations made of the annual grants between the years 1850 and 1870, both years included. These appropriations cover the whole of the receipts from the Treasury within the period thus specified, with the exception of 1,000*l*. repaid to the Treasury in 1861, and duly acknowledged by the Secretary of the Treasury in a letter dated January 24th, 1861. Thus, the sums received by the Royal Society by parliamentary grants between the years 1850 and 1870, and disbursed by the Government Grant Committee in the promotion of scientific discovery and research, amount in the aggregate to 20,000*l*.

The President and Council have always held themselves ready to furnish accounts of the appropriation of the Government Grants in successive years, whenever such accounts should be required either by Government or by Parliament; and such accounts have been so required, and have been so furnished at different times, and have been published in Parliamentary Papers, and in the Proceedings of the Royal Society.

APPROPRIATION of the GOVERNMENT GRANT, 1850 to 1854 inclusive.

The following account of the appropriation of the sum of 5,000*l*., placed by Her Majesty's Government in five annual sums of 1,000*l*. each, in the years 1850 to 1854 inclusive, at the disposal of the Royal Society, to be employed in aiding the promotion of science in the United Kingdom, has been presented to the Treasury, and is here printed for the information of the Fellows, by direction of the President and Council.

A.—Appropriation of the Government Grant of 1,000*l*. *in the year* 1850.

	£
1. For the publication of the observations made at the Armagh (private) Observatory for the re-observation of Bradley's Stars; the work so published to be the property of Her Majesty's Government	350
Publication completed in 1851.	
2. For the publication of Vol. I. of the Catalogue of Ecliptic Stars observed at the Markree (private) Observatory; the work so published to be the property of Her Majesty's Government	150
This work has been printed, and the greater part of an impression of 700 copies presented, in the name of the British Government, to public institutions at home and abroad, and to individuals cultivating astronomy in this and other countries, under the direction of a committee consisting of Sir John Herschel, the Astronomer Royal, and the Superintendent of the Nautical Almanac. The remainder of the impression is on sale at a low price; the proceeds to be credited to Her Majesty's Government.	
3. To Charles Brooke, Esq., to be employed in the construction of an instrument for the autographic registry of the variations of the terrestrial magnetic force corrected for temperature -	100
This instrument was completed and exhibited in the Great Industrial Exhibition for 1851.	
4. To T. Wharton Jones, Esq., to be employed in assisting him in investigations on inflammation	100
These investigations were in continuation of an inquiry in which Mr. Jones had been for some time engaged, and for which he had obtained, in 1850, the Triennial Prize of 300*l*., founded by Sir Astley Cooper. Their continuation has led to further publications in the Philosophical Transactions and in the Medico-Chirurgical Transactions, and is still in progress.	
5. To Professor Owen, to have drawings made of undescribed or unfigured parts of the skeleton of the Megatherium -	100
The drawings have been made and are deposited at the Royal Society, accompanied by a Memoir drawn up by Professor Owen, part of which has been published in the Philosophical Transactions, and the remainder is now in course of publication.	
6. To Lieut.-Colonel Sabine, for the purchase of magnetical and meteorological instruments of a new construction for trial of their merits at the Kew Observatory; the instruments to be the property of Her Majesty's Government	100
These instruments were purchased and their merits examined at the Kew Observatory; the results of the examination have been published in the Transactions of the British Association.	
7. To Dr. Stenhouse, to assist his researches into the chemical relations subsisting amongst the various genera of plants	100
This grant produced a valuable paper "On the action of Nitric Acid on various Vegetables," which was published in the Philosophical Transactions; and the full amount of the grant was subsequently placed again by Dr. Stenhouse at the disposal of the Committee, and became the subject of a fresh appropriation in 1853.	
Total sum appropriated in 1850 -	£1,000

B.—Appropriation of the Government Grant of 1,000*l*. *in* 1851.

	£
1. To Dr. Thurnam, to assist in procuring exact drawings of crania of early British races -	50
The drawings have been made, and are deposited, with an accompanying Memoir, at the Royal Society.	
2. To Professor Stokes, for experiments to determine the index of friction in different gases	175
These experiments are in progress at the Kew Observatory under Professor Stokes's direction.	
3. To Dr. Hofmann, for a continuation of his investigations respecting organic bases	100
These investigations were in continuation of researches of which the results were published in the Philosophical Transactions, and for which a royal medal was awarded. They are regarded by chemists as extremely important, and are still in progress.	
4. To the Astronomer Royal, for the reduction and publication of the late Rev. J. Catton's astronomical observations	50
These observations, extending from 1791 to 1852, have been reduced, and the results published in the Transactions of the Royal Astronomical Society.	
5. To John F. Miller, Esq., of Whitehaven, to obtain observations on the fall of rain, and on the minimum temperature in winter, at several stations in the Lake District of England	50
These observations have been communicated to the Royal Society, and the results have been published in "Reports on the Meteorology of the Lake District," by Mr. Miller.	

£

6. To Dr. W. B. Carpenter, for the execution of drawings of Foraminifera collected on the Australian coast during the surveying expedition of Her Majesty's ship "Fly" - 25

These drawings have been deposited at the Royal Society, and have served, together with similar drawings procured by grants in 1852 and 1854, as data from which Dr. Carpenter has drawn up an important Monograph on this class of animals, which was published in the Philosophical Transactions for 1856.

7. To Leonard Horner, Esq., for the analysis of specimens of the water of the Nile, and of the soil, at different depths in the valley of the Nile, which had been procured by the aid of a grant from the Donation Fund of the Royal Society - - 50

The results of this analysis have been published in the Philsophical Transactions.

8. To William Hopkins, Esq., of Cambridge, for investigations on the effect of pressure on the temperature of fusion of certain substances - 250

These important experiments, in which Mr. Hopkins has been assisted by Messrs. Fairbairn and Joule of Manchester, are still in progress (1855).

9. To Dr. Miller, Mr. Gassiot, and Colonel Sabine, representing the Kew Committee of the British Association, for the construction and verification of standard meteorological instruments. - 150

By the aid of this and of a subsequent grant of equal amount in 1852, the Kew Committee have been enabled to meet satisfactorily the extensive applications which have been made to them by the Governments of our own country and of the United States, to provide and verify meteorological instruments required for the marine meteorological researches undertaken by those Governments with a view to the interests of trade and navigation, as well as to those of general science.

10. To Professor Owen, to defray the cost of drawings of undescribed and unfigured fossils from South America and Australia 100

These drawings have been executed, and are 72 in number.

Total sum appropriated in 1851 - £1,000

C.—Appropriation of the Government Grant of 1,000*l.* *in* 1852.

£

1. To Professor William Thomson, of Glasgow, for experimental researches in several branches of electrical science - 50

This grant, as well as a subsequent grant of 50*l.* in 1853, was designed to assist in furnishing apparatus for various electrical researches in which Professor Thomson was engaged; the results, as far as they have yet been obtained, have been communicated to the Royal Societies of London and of Edinburgh, and published in their Transactions and in other scientific journals. The researches are still in progress.

2. To Dr. Tyndall, for experimental researches on the diathermic and conductive capacities of crystalline and other bodies 50

This money has been expended in providing apparatus for the experimental researches referred to. The results, so far as they have been yet obtained, have been published in papers in the Philosophical Transactions, and the researches are still in progress.

3. To Professor Williamson, for experimental investigations into the law of the chemical action of masses - 100

The experiments are in progress, and the results hitherto obtained will shortly be communicated to the Royal Society.

£

4. To Mr. Joule, of Manchester, for experiments on the effects of magnetism on the dimensions of iron and steel bars - - - - 30

These experiments are still in progress.

5. To Mr. John A. Dale, of Balliol College, Oxford, for experiments on the relation of metals with each other and with liquids in the voltaic circuit - - - 50

These experiments are still in progress.

6. To Professor Owen, for obtaining anatomical drawings of undescribed, existing, and extinct animals - - 100

Drawings, 43 in number, have been executed, and part of the grant yet remains to be similarly applied.

7. To Dr. Miller, Mr. Gassiot, and Colonel Sabine, for the construction and verification of standard meteorological instruments - - 150

See note to a similar appropriation in 1851, No. 9.

8. To Henry Gray, Esq., for investigations concerning the spleen - - - 100

The results of these investigations are published in an Essay on the Spleen, for which the triennial Astley Cooper prize of 300*l.* was awarded in 1853.

9. To Professor Beale, for investigations into the chemistry of morbid products 50

This investigation is still in progress.

10. To Dr. Carpenter, for the execution of drawings of Foraminifera 25

See note to a similar appropriation in 1851, No. 6.

11. For the publication of Vol. II. of the Markree Catalogue of Ecliptic Stars - 130

Vol. II. has been published, and the edition of 500 copies disposed of as in the case of Vol. I. (1850, No. 2).

12. To Professor William Thomson and Mr. Joule, for experiments on the thermal effects experienced by fluids in passing through small apertures - - - - - 100

The experiments referred to in this and in subsequent grants of 100*l.* in 1853, and of 200*l.* in 1854, are still in progress. A Memoir, describing part of the results obtained, has been presented to the Royal Society, and printed in the Philosophical Transactions.

13. To Dr. Frankland, for investigations into organo-metallic compounds - 65

The results of this investigation have been communicated to the Royal Society, in a Memoir which will appear in the forthcoming volume of the Philosophical Transactions.

Total sum appropriated in 1852 - £1,000

D.—Appropriation of the Government Grant of 1,000*l.* *in* 1853.

£

1. To Dr. Waller, for investigating the results of the section of nerves - 100

An interim report of the progress of this investigation has been received by the Royal Society.

2. To Dr. James Thompson, C.E., of Glasgow, and Mr. Fairbairn, of Manchester, for experiments on the friction of discs revolving in water, for the purpose of obtaining data required in calculations relating to turbine water-wheels and centrifugal pumps - 50

The results already obtained have been communicated to the Royal Society, and preparations have been made for renewing the experiments on a more extended scale.

3. To Captain Lefroy, for the expenses of preparing for publication observations on the Aurora Borealis made in North America — £ 20

The observations have been in great measure prepared for publication.

4. To Warren De La Rue, Esq., for mounting the Huyghenian object-glass of 123 feet focal length - 250

This, with an appropriation of equal amount in 1854, was designed to meet an application made to the Royal Society by M. Struve, of St. Petersburg, to compare the appearance of Saturn, as shown by the Huyghenian lens referred to, with that of the planet as seen in telescopes of modern date, in consequence of Huyghens's representation of the ring not according with its appearance as now observed. Difficulties have been met with in carrying out this object in the method first proposed, which have occasioned delay and the subject now stands for reconsideration.

5. To Professor William Thomson, of Glasgow, for experiments on the thermal effects of electric currents in unequally heated conductors 50

See note to a similar appropriation in 1852, No. 1.

6. To Professor William Thomson and Mr. Joule, for continuing the experiments on the thermal effects experienced by fluids in passing through small apertures 100

See note to a similar appropriation in 1852, No. 12.

7. To Dr. Marcet, for expenses connected with his researches on the excretions of man and animals 50

The results were communicated in a paper presented to the Royal Society, and printed in the Philosophical Transactions.

Total sum appropriated in 1853 -				£620	0	0
Balance to credit in 1854				480	10	11
Grant from Government - -	£1,000	0	0			
Replaced by Dr. Stenhouse	100	0	0			
Repaid from the Catton grant	0	7	0			
Repaid from the Ecliptic Stars' grant	0	3	11			
	£1,100	10	11	£1,100	10	11

E.—Appropriation of the Government Grant of 1,000*l. in* 1854, *and of a balance carried from the preceding year of* 180*l.* 10*s.* 11*d.*

1. To Robert Mallet, Esq., C.E., Dublin, for experiments on earthquake waves — £ 150

The apparatus for these experiments was prepared by means of a grant from the British Association. The experiments are proposed to be made at Holyhead, when a fitting time is arrived in the progress of the harbour works at that station.

2. To Dr. Marcet, for a continuation of his researches on the excretions of man and animals 50

See note to a similar appropriation in 1853, No. 7.

3. To Professor Eaton Hodgkinson, for experiments on the strength of material 100

This appropriation has been augmented by a gift of 200*l*. from Robert Stephenson, Esq., C.E. The experiments are in progress.

4. To Dr. Tyndall, for experimental researches in heat and magnetism 100

The results of a part of these researches have been presented to the Royal Society, and will be published in the forthcoming volume of the Philosophical Transactions.

5. To Dr. Woods, of Parsonstown, in Ireland, for experimental researches on the heat developed in the oxidation of certain metals 20

The experiments are in progress, and an interim report has been presented to the Royal Society.

6. To Professor William Thomson, of Glasgow, and Mr. Joule, of Manchester, for experimental researches on fluids in motion, and on the thermal effects experienced by fluids in passing through small apertures - £ 200

See note to an appropriation for the same purpose in 1852, No. 12, and in 1853, No. 6. A Memoir containing the results of these researches, so far as they have yet been completed, has been presented to the Royal Society, and printed in the Philosophical Transactions.

7. To Warren De La Rue, Esq., for mounting the Huyghenian object-glass - 250

See note to a similar appropriation in 1853, No. 4.

8. To T. H. Huxley, Esq., for the publication of his zoological researches. - 300

Mr. Huxley was employed under the orders of the Admiralty in a surveying expedition, under Captain Owen Stanley, during which these researches were made. On his return Mr. Huxley contributed two Memoirs to the Royal Society, for which the royal medal was awarded him. They were printed in the Philosophical Transactions. The publication of the whole of his researches has been strongly recommended by the highest authorities in this branch of science, and will be accomplished by this grant. The work itself will be the property of Her Majesty's Government, and will be distributed in a manner analogous to that of the Markree and Armagh Star Catalogues.

9. For the publication of Vol. III. of the Markree Catalogue of Ecliptic Stars 132*l*. 1*s*. 7*d*.

Vol. III. has been published, and the edition disposed of, as already described, in the cases of Vols. I. and II.

10. To Dr. W. B. Carpenter, for completing the illustrations of typical forms of Foraminifera 50

See note to an appropriation for the same purpose in 1851, No. 6.

11. To Nevil Maskelyne, Esq., of Oxford, for chemical researches on the solid oils and waxes of the vegetable kingdom - 100

These researches are in progress.

12. To Dr. Pavy, for continuing experimental researches on the physiology of the blood, of which a part has been recently communicated to the Royal Society - 50

The researches are in progress.

13. To Professor William Thomson, for experiments on the thermal effects of electric currents in unequally heated conductors 50

The experiments are in progress.

Total sum appropriated in 1854 - £1,552 1 7

Total Grants and Appropriations.

Grants.	£	s.	d.	Appropriations.	£	s.	d.
1850	1,000	0	0	1850	1,000	0	0
1851	1,000	0	0	1851	1,000	0	0
1852	1,000	0	0	1852	1,000	0	0
1853	1,000	0	0	1853	620	0	0
1854	1,000	0	0	1854	1,552	1	7
Replaced by Dr. Stenhouse	100	0	0				
Small balance returned from the Markree and Catton grants	0	10	11				
Total	£5,100	10	11	Total	£5,172	1	7

The appropriations exceed the sums placed at the disposal of the Royal Society by 71*l.* 10*s.* 8*d.*, which it was the intention of the Council to have provided out of the expected grant of 1,000*l.* in 1855.

(Signed) Edward Sabine,
V.-P. and Treasurer R.S.

Somerset House, July 20, 1855.

Appropriation of the Government Grant, 1855 to 1870 inclusive.

A.—Account* of the appropriation of the sum of 1,000*l.* annually voted by Parliament to the Royal Society (the Government Grant), to be employed in aiding the Advancement of Science. The present statement is in continuation of that already given up to April 5th, 1855.

1855.

	£
1. To the Rev. F. Bashforth, for inquiries concerning capillary attraction	50
2. To Dr. Miller, on behalf of the Kew Observatory, for the construction and verification of standard meteorological instruments	100
3. To Dr. Salter, for inquiries in experimental physiology	50
4. To Dr. Frankland, for continuation of his researches on organo-metallic bodies	100
5. To Mr. Fairbairn, for experiments on the explosions of steam-boilers	300
6. To Professor E. Hodgkinson, for continuing his experiments on the strength of materials	100
7. To Dr. Carpenter, for researches in marine natural history	50
8. To Mr. H. F. Baxter, for researches in electro-physiology	30

1856.

1. To Dr. Gladstone, for researches on chemical affinity	50
2. To Dr. Tyndall, for continuing researches in magnetism	100
3. To Mr. Cooper, for expense of printing the fourth and last volume of his Catalogue of Ecliptic Stars	140
4. To Dr. Harley, for continuing his researches on the chemistry of respiration	50
5. To Mr. Greville Williams, for an investigation of the products of distillation of coal at low temperatures	50
6. To Mr. Lockhart Clarke, for investigations into the structure of the *Medulla oblongata* and *Pons Varolii* of man, and some of the vertebrata	30
7. To Dr. Brown-Séquard, for researches on the vital properties of muscles, nerves, and the spinal chord	60
8. To Professor William Thomson, for continuing his electrical researches	100
9. To Professor Eaton Hodgkinson, for continuing his experiments on the strength of materials	100
10. To Dr. Carpenter, for the prosecution of his researches on marine natural history	50
11. To Professor Owen, for obtaining drawings of the *Scelidotherium leptocephalum* and other extinct animals	50

1857.

	£
1. To Dr. Waller, for prosecuting his investigations on the nervous system	50
2. To Mr. Hopkins, for continuation of his researches on the effect of pressure on the melting-point of solids	150
3. To Dr. Roscoe, for prosecuting photo-chemical researches, in association with Professor Bunsen	100
4. To Professor W. Thomson, for electrical researches	50
5. To Mr. Beckles, for further prosecuting the search for fossil remains of Mammalia in the Purbeck strata	150
6. To Dr. Debus, for prosecuting investigations on the action of nitric acid on alcohol	50
7. To Mr. Greville Williams, for continuing his researches on the products of distillation of Boghead coal	50
8. To Mr. Henry Lee, for the investigation of morbid processes, arising from affections of the blood vessels and their contents	25
9. To Dr. Brown-Séquard, for continuing his researches on the vital properties of nerves and muscles, and on animal heat	100
10. To the Committee of the Kew Observatory, for completing new photographic magnetic instruments, now in process of construction at the observatory	150

1858.

1. To Dr. Edward Smith, for prosecuting his researches on respiration	100
2. To Mr. Mallet, for conducting investigations on the spot, of the phenomena resulting from the recent earthquakes in the Neapolitan territory	150
3. To Mr. Greville Williams, for researches on the constitution of the oil of rue, and on the influence of temperature and pressure on the densities of vapours	100
4. To Mr. Matthiessen, for researches on the law by which alloys conduct electricity	50
5. To Mr. Gore, for an inquiry into the molecular states of metals	50
6. To Mr. Wanklyn, for researches on a new series of bodies containing potassium and sodium	50
7. To Professor Tyndall, for continuing his researches on glaciers	15
8. To Dr. Frankland, for continuing his researches on organo-metallic bodies	100
9. To Mr. Hopkins, for continuing his researches on the effect of pressure on the melting-points of solids	150
10. To Dr. Pavy, for researches on the physiology of the liver	50
11. To Mr. Matthiessen, for researches on the action of nitrous acid on natural organic bases	50

1859.

1. To Mr. Mallet, for obtaining photographs of the earthquake phenomena in the Neapolitan territory	50
2. To Professor Owen, for procuring drawings and other illustrations of new and undescribed subjects of comparative anatomy and palæontology	100
3. To Professor William Thomson, for defraying expenses already incurred, and continuing his researches on the electro-dynamic qualities of metals	100
4. To the Brixham Cave Committee, for continuing the excavations	100
5. To Dr. Tyndall, for investigating the minimum temperature both of the air and of the ice at various elevations on Mont Blanc	100

1860.

1. To Mr. J. P. Joule, for experiments on surface condensation	50
2. To Dr. Pavy, for continuing his chemico-physiological researches	50
3. To Dr. Maxwell Simpson, for continuing his researches on glycol	50
4. To Mr. W. Fairbairn, for researches on the density of steam	60
5. To Professor William Thomson, as an electrical committee of the British Association, for the construction of self-recording electrical instruments	100
6. To Mr. C. Greville Williams, for continuing his researches on euodic aldehyde, &c.	100
7. To the Rev. Dr. Robinson, for the completion of the Armagh catalogue of stars	56*l.* 15*s.* 8*d.*
8. To Mr. A. Matthiessen, for researches on the conducting powers for heat and electricity, and on the coefficients of expansion, of metals and alloys	50
9. To Mr. G. Gore, for continuing his researches on electro-deposited antimony, and for further examining the movements of liquid metals and electrolytes in the voltaic circuit	
10. To Mr. T. Rupert Jones and Mr. W. K. Parker, for the completion and publication of drawings of the Foraminifera	100

---

* By resolution of the Council of Dec. 15, 1870, it has been ordered that accounts of the expenditure of the Government Grant, and of the sums granted from the Donation Fund, shall be published annually in the Proceedings, with the Report of the Anniversary Meeting.

	£
11. To Mr. Warren De La Rue, for expenses of conveying the Kew photoheliograph to Spain, and travelling expenses of two assistants, to obtain photographs of the solar eclipse of 18th July 1860	150

1861.

1. To Dr. Pavy, for continuing his researches on the physiology of the liver	100
2. To Dr. Joule and Professor Thomson, for completing their researches on the thermal effects of fluids in motion	150
3. To Professor Beale, for the augmentation of the powers of microscopes with reference to their employment in physiological researches	50
4. To Mr. Maxwell Simpson, for researches on the cyanides of the diatomic and triatomic radicals	50
5. To Dr. Frankland, for examining the action of zinc-ethyl and analogous bodies on silicic, carbonic, and oxalic ethers	100
6. To Mr. Mallet, for the publication of his earthquake report (to be applied to the illustrations)	300
7. To Mr. Balfour Stewart, for researches on the diathermancy of bodies	50
8. To Mr. Balfour Stewart, for experiments to determine accurately certain melting-points, to be used as standard points for high and low temperatures	150
9. To Mr. Hopkins, for continuing his researches on the specific heat, expansibility, and temperatures of fusion under pressure of certain substances	100
10. To Professor Tyndall, for investigating the relations of gases and vapours to radiant heat	200
11. To Mr. Cayley, for certain analytical calculations	20

1862.

1. To Dr. J. D. Hooker, for procuring drawings to illustrate the description of a new and remarkable plant discovered in Angola by Dr. Wellwitsch	50
2. To Mr. E. W. Binney, for defraying the expenses attending the investigation of structural specimens of coal fossils of remarkable interest and perfection	50
3. To Dr. E. Smith, for researches with a view to determine the relations of nitrogen in the food and egesta of patients afflicted with fever and phthisis	50
4. To Professor J. Phillips, for defraying the cost of maintaining, and the incidental expenses of working, a telescope at Oxford for the special examination of the moon's surface	100
5. To Professor W. Thomson, for experimental researches, (1) on contact electricity, (2) on the absolute conducting-powers of different substances for heat	50
6. To Professor W. Thomson, for observation of atmospheric electricity: for instruments to be entrusted to Mr. B. Stewart, Kew	14*l*. 10*s*.
7. To Mr. G. Gore, for continuing his experiments on the electrolytic vibrations of mercury, and other allied matters	50

1863.

1. To Dr. Waller, for experiments on a means of avoiding the danger attending the administration of the vapour of ether or chloroform, and for investigating lead-poisoning	50
2. To Professor Maxwell Simpson, for further researches on cyanides of the di- and triatomic radicals	50
3. To Mr. Warren De La Rue, for the continuation at Kew, for one year, of the observations with the photoheliograph	200
4. To Professor Selwyn, for obtaining autographs of the sun	50
5. To Mr. Mallet, for determining the temperature of volcanoes	100
6. To Dr. Matthiessen, I. for a research into the thermo-electric behaviour of alloys, to be carried out in conjunction with Mr. Matthews	25
7. II. For a research into the expansion by heat of metals and alloys, to be carried out in conjunction with Dr. Dupré	25
8. III. For a research into the conduction of heat by metals and alloys, to be carried out in conjunction with Dr. Schunck	25
9. To Mr. Crookes, for continuing his researches on Thallium	200
10. To Dr. Frankland, for continuing his researches on organo-metallic bodies	100
11. To Professor William Thomson, for procuring instruments for the observation of atmospheric electricity in Nova Scotia	20
12. To Mr. W. R. Birt, for the purchase of a 4-inch object-glass for observing the physical features of the moon	60
13. To Dr. W. A. Miller, for apparatus for the investigation of the spectrum	150

1864.

1. To Mr. R. C. Carrington, towards defraying the cost of printing and publishing his observations of solar spots	250
2. To Mr. T. A. Malone, for investigating the nature of the action and results obtained in the daguerreotype and photographic processes	50
3. To the Rev. Dr. Robinson, for reducing a series of anemometric registrations	125
4. To Mr. Gassiot (on behalf of the Kew Committee), for obtaining copies of magnetic curves taken at Kew, for distribution	50
Ditto, ditto, for procuring a self-recording anemometer for observations to be taken at the Island of Ascension	69*l*. 1*s*.
5. To Dr. Pavy, for physiological researches into the stomach and liver	50
6. To Mr. F. Jenkin (on behalf of a committee of the British Association), to supplement grants voted by the British Association for the construction of four standard electrical instruments for the observatory at Kew	50
7. To Dr. Matthiessen, for further researches into narcotine	30
8. To Mr. Schorlemmer, for investigations into the whole series of the so-called alcohol radicals	30
9. To Mr. De La Rue, for continuation of photoheliography at Kew till February 1865	150
10. To Dr. Richardson, for an inquiry into the best means of restoring suspended animation	50
11. To Professor Tyndall, for researches on radiant heat as applied to Molecular Physics	100
12. To the Rev. H. Tristram, for expenses of a botanical collector in the expedition to the shores of the Dead Sea and adjacent country	50

1865.

1. To Mr. De La Rue, for continuing the observations with the Kew photoheliograph to November 1865	100
2. To Mr. Balfour Stewart, for defraying the cost of obtaining and distributing magnetic curves	100
Ditto, for repair of pendulums, and fitting a room at Kew for base observations	200
3. To Dr. Frankland, for continuing his researches on the synthesis of organic compounds	100
4. To Dr. Maxwell Simpson, for continuing his researches on the polyatomic radicals	50
5. To Mr. R. C. Carrington, for reducing Weisse's and Oeltzen's Catalogue of Stars	90
6. To the Rev. C. Pritchard, for arranging and computing tables for facilitating the construction of aplanatic object-glasses	60
7. To the Rev. Dr. Robinson (on behalf of a committee of the British Association), for experiments on submarine fog-signals	100
8. To Dr. Falconer, in furtherance of a determination by levelling of the exact depression of the Dead Sea (the amount to be placed at the disposal of Col. Sir Henry James)	100
9. To Professor Stokes, for determining, by means of pendulums, the index of friction of gases and vapours	100
10. To Mr. F. Galton, for an apparatus for verifying sextants in connexion with Kew Observatory	80
11. To Dr. Richardson, for continuing his inquiries into the means of restoring suspended animation	50
12. To Mr. G. J. Symons, for the salary of an assistant to be employed in collecting and classifying rainfall statistics	50
13. To Mr. De La Rue, for continuation at Kew Observatory of observations on sun-spots	150
14. To the Rev. G. C. Hodgkinson, for actinometrical instruments and observations	30

1866.

		£
1.	To Professor Stokes, for continuing his experiments on the index of friction of gases and vapours - -	75
2.	To Sir Henry James, for half the excess of the expense of levelling to determine the exact depression of the Dead Sea, over the sums granted by the Royal Society and the Royal Geographical Society for the purpose	7l. 7s. 9d.
3.	To Mr. F. Jenkin, for the construction of a standard electrodynamometer - -	75
4.	Ditto, for the construction of a standard condenser, or leyden-jar	75
5.	To Mr. B. Stewart, for determining the origin of the heat observed in a revolving disk - -	50
6.	Ditto, for determining the rate and length of Kater's invariable pendulum	100
7.	To the Rev. A. Weld, for half the expense of establishing a magnetic observatory at Stonyhurst	225
8.	To Mr. G. Bentham and others, for preparing a catalogue of all described phænogamous plants	50
9.	To Professor Huxley, towards defraying the cost of coloured plates for a work, by Mr. Parker, on the sternum and shoulder-girdle of the vertebrata - -	100

1867.

		£
1.	To Mr. De La Rue, for working the Kew photoheliograph during the current year -	200
2.	To Mr. J. N. Lockyer, for the purchase of a large spectroscope, and of fitting the same to his telescope, to be employed in spectroscopic observations of the sun -	40
3.	To Dr. Gamgee, for investigating the action of carbonic oxide and other poisonous agents upon blood -	50
4.	To the Rev. G. C. Hodgkinson, for continuing his actinometrical researches - -	30
5.	To Dr. Frankland, for continuing his synthetical researches on ethers - - - -	100
6.	To Mr. Breen, for the correction of the elements of the orbits of Jupiter and Saturn	50
7.	To Dr. Carpenter, for defraying the expenses incurred in the prosecution of his researches in marine zoology - -	100
8.	To Mr. De La Rue, for reducing Schwabe's observations of sun-spots - -	60
9.	To Mr. Scott (as secretary of the Greenland committee of the British Association), for the exploration of the tertiary plant beds of North Greenland - -	200
10.	To Mr. B. Stewart, for an apparatus for verifying sextants in connexion with Kew Observatory (in addition to the former grant) -	40
11.	To Dr. Frankland, for investigating the luminosity of various flames under pressure	25
12.	To Dr. Bigsby, for assisting in the publication of his work entitled "Thesaurus Siluricus," it being understood that 50 copies would be placed at the disposal of the Royal Society, and 50 copies at the disposal of the Geological Society for distribution	100
13.	To Prof. Roscoe, for continuing his experiments on the chemical intensity of total daylight -	100

1868.

		£
1.	To Mr. Herbert Jenner Fust, for assistance to-towards the publication of a paper "On the Distribution of Lepidoptera in Great Britain and Ireland" - -	25
2.	To Dr. Maxwell Simpson, for continuing his researches on the cyanides of the alcohol radicals and their derivatives - -	100
3.	To Dr. Matthiessen and Mr. Hocken, for a research into the conducting-power of liquids for electricity - -	40
4.	To Dr. Matthiessen and Mr. R. Sabine, for apparatus for prosecuting a research into the determination of high temperatures by means of a new pyrometer - - - - -	50
5.	To Mr. R. Scott (on behalf of the Greenland committee of the British Association), for defraying some additional expenses connected with the collection of Greenland fossils -	25
6.	To Mr. G. J. Symons, for a continuation of rainfall observations -	100
7.	To Mr. C. Brooke, for construction of a spectroscope with six rock-salt prisms - -	60
8.	To Mr. G. Bentham, for bringing up the catalogue of phænogamous plants at the Kew Herbarium to a point from which it can be continued by the ordinary staff - -	25
9.	To Mr. B. Stewart, for continuing his experiments on a rotating disk - - - -	60
10.	To Mr. De La Rue, for continuing the Kew photoheliographic observations - -	200
11.	To the treasurer of the Royal Society, for defraying the expense of instruments sent to India - - -	284l. 18s. 6d.
12.	To Mr. W. Carruthers, for illustrations of British fossil cycadeæ - - - - -	50

1869.

		£
1.	To the Rev. S. Haughton, for investigation of the granites of Scotland - -	50
2.	To Mr. G. J. Symons, for comparison of the effect of different forms of thermometer stand - - -	15
3.	To Mr. F. Guthrie, for prosecuting experiments on the thermal resistance of liquids	50
4.	To Mr. G. Gore, for continuing his researches on the fluorides -	150
5.	To Mr. E. T. Chapman, for a research on the physical properties of organic bodies - -	50
6.	To Dr. Sanderson, for further researches on respiration and the circulation of the blood	50
7.	To Mr. F. Galton, for the construction of his anemometer - - -	15
8.	To Mr. De La Rue, for continuing the Kew photoheliographic observations -	200
9.	To Mr. J. N. Lockyer, for a continuation of his spectroscopic observations on the sun -	60
10.	To Professor Cayley, Mr. Clerk Maxwell, Professor Sylvester, for the construction of models of certain geometrical surfaces -	40
11.	To Dr. Carpenter, for the further prosecution of researches into the temperature and zoology of the Deep Sea - -	200
12.	To Mr. Dupré and Mr. F. J. Page, for continuing their investigations on the specific heat and other physical characters of aqueous mixtures and solutions - - -	70

1870.

		£
1.	To Mr. G. J. Symons, for comparison of the effect of different forms of thermometer stand, in addition to the former grant -	30
2.	To Professor Tait, for an inquiry into thermal conductivity - - - -	50
3.	To Mr. R. Field, for experiments to determine the amount of evaporation from a water-surface -	30
4.	To Mr. A. Dupré, for continuing investigations on the specific heat and other physical characters of aqueous mixtures and solutions -	30
5.	To Mr. F. Galton, for excess of cost of his anemometer - - -	7l. 19s. 6d.
6.	To Mr. De La Rue, for continuing the Kew photoheliographic observations -	200
7.	To Mr. Schorlemmer, for continuing his researches on the hydrocarbons - -	30
8.	To Dr. Carpenter, for the scientific expenses of a contemplated dredging expedition - -	100

Total Grants and Appropriations.

GRANTS.

	£	s.	d.	£	s.	d.
				16,000	0	0
Repayments:—						
W. De La Rue -	269	16	0			
L. Horner -	20	0	0			
Professor Stokes	175	0	0			
Sundry	0	5	0			
W. Hopkins	100	0	0			
R. H. Scott	7	5	3			
				572	6	3
Interest				97	15	2
				£16,670	1	5

APPROPRIATIONS.

	£	s.	d.
	13,970	12	5
Overdrawn in 1854 - - -	71	10	8
Petty charges - - - -	0	14	2
	14,042	17	3
Repaid to the Treasury - -	1,000	0	0
Balance November 30, 1870 -	1,627	4	2
	£16,670	1	5

WILLIAM SPOTTISWOODE,
V.-P. and Treasurer R.S.

The Secretary's letter intimates that "much interest "would be felt in the history of any fund or endowment "for the special use of the Society, as well as of the "accommodation provided in public buildings."

There is at the disposal of the Royal Society a fund or endowment, called "the Donation Fund," not derived in any way from Government, but consisting exclusively of donations and bequests from Fellows of the Royal Society. It originated in a donation from the late Dr. W. Hyde Wollaston of 2,000*l.* consols towards the creation of a fund "for the promotion of natural knowledge (the object "for which the Royal Society was founded). The dividends "are directed to be applied from time to time 'in promoting "'experimental researches, or in rewarding those by whom "'such researches may have been made; or in such other "'manner as shall appear to the President and Council for "'the time being most conducive to the interests of the "'Society in particular or science in general.' It is further "enjoined that the dividends are not to be hoarded parsimoniously, but expended liberally, as nearly as may "be *annually*, in furtherance of the declared objects of the "trust."

This fund has subsequently been increased by donations from time to time by other Fellows, and now furnishes an income of 156*l.* 18*s.* 11*d.*, which is applied in the manner directed.

As regards accommodation in public buildings, the Royal Commission is aware that the business of the Royal Society is at present conducted at Burlington House, and will hereafter be carried on in one of the buildings now in the course of erection at that locality.

It may be proper to notice at this stage the pecuniary assistance which the Royal Society has received from Her Majesty's Government in carrying into execution a project adopted by the Royal Society of publishing a "Catalogue of Scientific Papers." As the Secretary of the Royal Society, Dr. Sharpey, has taken a principal part in the preparation of this Catalogue, I have obtained from him, and subjoin with my own authentication, a memorandum on the origin and progress of that undertaking.

A Memorandum concerning the Royal Society's "Catalogue of Scientific Papers," drawn up by Dr. Sharpey, Secretary of the Society, at Sir Edward Sabine's request.

The Catalogue of Scientific Papers is intended to serve as an index to the titles and dates of scientific papers contained in the Transactions of societies, journals, and other periodical works which have been published from the beginning of the present century to the end of the year 1863.

A proposal for the formation of a catalogue of this nature, but with a much more limited scope, had been submitted to the British Association in 1855, and referred for consideration to a committee of that body, who reported favourably on the project; but no step was taken for carrying it into effect.

In 1857 the subject was brought before the President and Council of the Royal Society by General Sir Edward Sabine, then Treasurer and Vice-President; and in 1858 the President and Council, adopting the recommendations contained in a report of the Library Committee, resolved that the preparation of a catalogue of scientific memoirs should be undertaken by the Royal Society independently, and at the Society's own charge. It was then also determined not to limit the scope of the catalogue to physics and mathematics, as had been contemplated in the proposal considered by the British Association, but to extend it to the several branches of natural knowledge for the promotion of which the Royal Society was instituted, excluding matter of purely technical or professional character.

The work was accordingly begun without delay, and has been carried on under the superintendence of the Library Committee of the Royal Society.

A large proportion of the periodical works containing the papers to be included in the catalogue was at hand in the Royal Society's library, and to these very extensive additions have been made during the progress of the work; but recourse was also had to the library of the British Museum and other scientific libraries in this country available for the purpose, and valuable contributions were also obtained from abroad.

After due consideration it was decided that the compilation should consist of, first, the titles of papers printed in full and arranged alphabetically according to the authors' names; and, secondly, an alphabetical index of the subjects of the papers, so far as they appear in the titles.

In resolving on this undertaking the Council did not propose to task the society with more than the preparation of a *manuscript* catalogue for use in their own library, but it was hoped that eventually the catalogue might be printed for general use at the public expense, or by means of funds contributed from other sources; and when the preparation of the manuscript approached completion, it became expedient to take steps for effecting this object.

The publication of the work was evidently calculated to be of much public advantage, and as the Royal Society had already expended a large sum on its compilation, and were prepared to undertake the further expense of arranging it for printing and correcting the press, it was resolved to propose to Her Majesty's Government that it should be printed at the cost of the nation; and that, after the presentation of a certain number of copies to scientific institutions at home and abroad, the remainder should be offered for sale at the price of paper and printing only, and the proceeds applied in the reduction of the outlay on the part of the Government.

A communication was accordingly made to Viscount Palmerston, First Lord of the Treasury; and the proposal of the President and Council, having been favourably received by his Lordship and by Mr Gladstone, then Chancellor of the Exchequer, was approved by the Lords Commissioners of the Treasury. The minute of their Lordships, dated 28th November 1864, adopting the proposal, concludes in the following terms:—

"Having regard to the importance of the work, with "reference to the promotion of scientific knowledge generally, to the high authority of the source from which it "comes, and to the labour gratuitously given by members "of the Royal Society to its production, my Lords consider themselves justified in having the work printed "at the cost of the public, with the understanding that, "reserving such number of copies for presentation as my "Lords, in communication with the President of the "Royal Society, may hereafter determine, the work shall "be sold at such a price as it may be calculated will repay "the cost of printing.

"Their Lordships, however, desire it to be understood "that the work shall go forth to the public under the "authority of the Royal Society, by the exertions of whose "members this important aid to the study of science has "been produced."

The printing has accordingly been carried on by Her Majesty's Stationery Office, and four volumes have now been issued; the first in November 1867, the fourth in 1870, and good progress is also made with a fifth. It is expected that the whole of the first part, containing the titles arranged alphabetically under authors' names, will be completed in six volumes. Meanwhile arrangements are being made for the preparation of an index *according to subjects*, as originally contemplated.

1,000 copies of each volume are printed; 250 have, with the concurrence of the Treasury, been reserved for presentation to scientific institutions and individuals at home and abroad; and of these 126 have been already distributed. The proceeds from copies sold amount to 500*l.*, which has been paid into the Exchequer.

The total expense defrayed by the Royal Society up to this date, March 24th, 1871, amounts to 3,400*l.* For this outlay the Royal Society looks for no pecuniary return.

The notice which I have received from the Secretary of the Royal Commission proceeds to acquaint me that "the "Royal Commission have reason to believe that the "Government have not acted without communication with "the Council of the Royal Society in the large outlay "incurred in the 'Magnetic Surveys,' or 'in the foundation of the Department of Meteorological Observations,' "or 'in the various Dredging Expeditions, and other "scientific inquiries; and the Commission would be "glad to have such a report, or such evidence on these "several matters as might aid them in their deliberations "as to the definition of the most useful relations of the "Government with the scientific associations, and especially with the Royal Society."

With permission, I propose to reply to these inquiries by taking them severally in the succession in which they are named:—

Magnetic Surveys.

First, as to "the large outlay incurred in the Magnetic Surveys."

The revival in this country and in our times, of the interest in the Advancement of the Science of Terrestrial Magnetism, which, nearly two centuries ago, gave rise to the memorable voyage of Halley (1699–1700), originated in the expeditions for *geographical discovery and scientific research in the North Polar regions*, which in 1818 (at the close of the great European War) were undertaken by the British Government, chiefly at the recommendation of the Royal Society. The regions thus visited were of peculiar interest in respect to the magnetism of the globe, inasmuch as they were believed to include two localities of special interest in the magnetic theory, viz.—1st, the locality in the Northern Hemisphere in which the magnetic intensity attains its greatest force; and 2nd, the locality (distinct from and not necessarily coinciding with the former) where the forces, respectively due to magnetism and to gravitation, coincide in direction. In the earlier days, when speculation preceded research, these two points, each of primary importance in the theory of terrestrial magnetism, were merged in a single point, which was imagined to unite the properties of both. The failure of this hypothesis to represent or accord with the few and scattered observations collected by Halley at the end of the 16th century sufficiently attested the expediency of a special and crucial research. Reliable information in regard to the geographical positions of these two localities, corresponding to some definite epoch of time, had therefore been for some time anxiously desired by physicists, and there was reason to expect that both might be found within the limits comprehended by the explorations commenced in 1818. The realization of this expectation, combined with the results of the magnetic researches by Lütke, Wrangel, and Anjou on the European and Asiatic coasts of the Polar Sea, and of the magnetic surveys of Hansteen and Erman in the northern and central parts of Europe and Asia, together with the sea observations of Erman in the corvette, the "Krotkoi," in the Pacific and Atlantic Oceans, in the return voyage from Kamtchatka to St. Petersburg, drew the attention of physicists generally to the importance of a still further extension of surveys of corresponding character.

About the same time the attention of the public in general was drawn to the subject of the magnetic phenomena by the researches instituted by Humboldt in Berlin and by Gauss in Gottingen, relating to *magnetic disturbances*; and thus a disposition was excited in the public mind to encourage further researches in the same direction, which those who had been engaged in the preceding inquiries were not slow to profit by.

In the year 1832 the British Association for the Advancement of Science was formed, having for its object "to give "a stronger impulse and more systematic direction to "scientific inquiry, and to obtain a greater degree of "national attention to the objects of science." The method by which the British Association, in the early years of its existence, sought to attain these objects, especially in cases in which the assistance of Government was needed, was by appointing a person, believed to be competent to the task, to present a report to the Association, showing what had been already accomplished, and what were the further steps most immediately desirable. In cases where national aid had to be sought, a full and somewhat precise statement was requisite as to the extent and nature of the aid to be solicited. Such a report having been asked for from myself regarding terrestrial magnetism, was presented and read at the meeting of the Association at Newcastle in 1838. It was entitled "*On the Variations of the Magnetic Intensity observed at different points of the Earth's Surface.*" It contained an exposition of what had already been accomplished by recent investigation, and of what still awaited accomplishment. Foremost under the latter head was placed "the filling the void still existing in the Southern Hemisphere, and particularly in the vicinity of the parts of that "hemisphere which are of principal magnetic interest. "This could only be accomplished by a naval expedition, "for which it was natural that all countries should look to "England."

The general approval with which the recommendations of that report were received by the Association cannot be better shown than by the following extract from the Anniversary Address (1838) of the then General Secretaries of the British Association, the Dean of Ely (Dr. Peacock) and Sir Roderick Murchison:—"Viewed in itself and in its "various relations, the magnetism of the earth cannot be "counted less than one of the most important branches of "the physical history of the planet we inhabit; and we "may feel quite assured that the completion of our knowledge of its distribution on the surface of our earth "would be regarded by our contemporaries and by posterity as a fitting enterprise of a maritime people, and a "worthy achievement of a nation which has ever sought "to rank foremost in every arduous and honourable "undertaking."

Together with the distinct proposition of a southern magnetic survey embodied in the Report, the British Association desired to bring under the consideration of Her Majesty's Government the desirability of taking part in the system of simultaneous magnetic observations which had been for some time carried on in Germany and other parts of Europe, by the institution of similar observations in various parts of the British empire, specially indicating Canada, St. Helena, Van Diemen's Land, and the Cape of Good Hope as suitable localities.

At the same meeting of the Association a committee was appointed consisting of Sir John Herschel, Mr. Whewell, Dr. Peacock, and Professor Lloyd, to "represent these recommendations to Her Majesty's Government." The first step taken by this committee was to obtain the co-operation of the Royal Society; and a joint committee, representing both institutions, was appointed, upon whom the duty devolved of obtaining the sanction of Government, and of arranging with the departmental authorities of the Admiralty and the Ordnance the aid required for the Antarctic Survey and for the Colonial magnetic observatories.

The application to Her Majesty's Government having been most favourably received, a naval expedition was appointed, consisting of two ships, the "Erebus" and "Terror," of the same class as those which had been emyloyed in the North Polar voyages, the "Erebus" commanded by Captain James Clark Ross, and the "Terror" by Commander Francis Rawdon Crozier, both officers who had been trained in the northern voyages. Captain Ross was directed to make Van Diemen Island his winter station while prosecuting the survey during three successive summers. He also took out with him to Van Diemen Island the observers and instruments for a Colonial magnetic observatory at that station. The establishment of the three other Colonial observatories, viz., in Canada, St. Helena, and the Cape of Good Hope, was undertaken by the Master-General of the Ordnance, Sir Hussey Vivian, who appointed to each an officer of the Royal Artillery and a suitable detachment of non-commissioned officers of the same corps. The officers were directed to act under my superintendence, and an office was assigned to me at Woolwich, to which the observations were to be transmitted for examination, reduction, and publication. The magnetical and meteorological observations made at the four Colonial observatories (including Van Diemen Island) have been thus published in 11 volumes, printed at the Stationery Office, and distributed according to a list approved by Government. The observations of the naval survey having in like manner been transmitted through the Admiralty to the Woolwich office have been reduced at that office, and discussed and published in a series of papers in the Philosophical Transactions; thus completing the magnetic survey of the higher latitudes of the *Southern* Hemisphere.

Additional Survey in the South Polar Regions by the bark "Pagoda."

On examining the records of the observations of the "Erebus" and "Terror," transmitted by the Admiralty to the Woolwich office, it appeared that a portion of the Southern Hemisphere, between the latitudes of 60° and 65° and the longitudes of 0° and 130° E., had not been included in the survey of the "Erebus" and "Terror" and still remained a "desideratum." On a representation being made by the President of the Royal Society to the First Lord of the Admiralty in June 1844, the "Pagoda," a bark of 360 tons, was hired at the Cape of Good Hope, and fitted for the required service, receiving a complement of four officers and 38 seamen from the flag-ship at that station. Lieut. T. E. L. Moore, R.N., who had been one of the officers of the "Terror" in the Antarctic Expedition, and was consequently accustomed to the navigation of the high latitudes, as well as practised in magnetic observations, was selected to command the "Pagoda," and with him was associated Lieut. Henry Clerk, of the Royal Artillery, who had been attached by Lord Vivian, Master-General of the Ordnance, to the magnetic observatory at the Cape of Good Hope, with the express view of taking such part as might be desired in a magnetic survey either by sea or by land. The "Pagoda" sailed from the Cape of Good Hope in January 1845, and returned in the following June, having completed the survey. The magnetic observations transmitted to the Admiralty were sent to the Woolwich office for reduction, and were published, as those of the "Erebus" and "Terror" had been, in the Philosophical Transactions, forming therein No. VIII. of the "Contributions to Terrestrial Magnetism."

Magnetic Survey of Canada.

In the Report already adverted to, presented to the British Association in 1838, special mention was made of the large continental spaces still vacant in our magnetic maps, and specially in Canada and India. The selection of Toronto as the site of one of the Colonial magnetic observatories, and the establishment of the observatory at Toronto in 1840, supplied a fitting head-quarters for a magnetic survey of the great continental space comprehended between the Polar Sea and the river St. Lawrence on the *north* and *south*, and between Hudson's Bay and the Rocky Mountains on the *east* and *west*. On application being made to the Master-General of the Ordnance an additional officer and non-commissioned officer were added to the complement of the Toronto Observatory for the express purpose of accomplishing the survey. This service was executed in 1843 and 1844 by Lieut. (now Major-General) John Henry Lefroy, of the Royal Artillery, and Sergeant Henry, of the same corps, aided by the facilities for traversing an unsettled country afforded by the Hudson's Bay Company, the expenses being defrayed by Her Majesty's Treasury. The greater part of this extensive and admirably conducted survey, including valuable contributions by observers of the United States, M. M. Graham, Locke, Bache, Loomis, Renwick, and Nicollet, was published in No. VII. of the Contributions to Terrestrial Magnetism in the Philosophical Transactions for 1846, and some portions not then included are now prepared, and are about to be published.

Lieut. T. E. L. Moore's Magnetic Voyage in the "Prince Albert" from England to Hudson's Bay, and return.

These observations were made in the summer of 1846 in the Hudson's Bay Company ship the "Prince Albert," in a voyage from the Thames to Moose Fort, in Hudson's Bay, and back, in which Lieut. Moore embarked by direction of the Admiralty for the purpose of making magnetic observations in compliance with a recommendation to that effect from the Royal Society. The declination results were published in the Contributions to Terrestrial Magnetism, No. IX., in the Philosophical Transactions for 1849. Those of the inclination and of the intensity will find their place in the magnetic maps of the high latitudes of the Northern Hemisphere, in a paper now preparing for the Philosophical Transactions.

Sir John Franklin and Captain Crozier's North Polar Expedition in 1845.

In none of the preceding northern voyages had the supply of magnetical apparatus been on so complete or on so extensive a scale as in this voyage. Each of the two ships was fully provided, not only with the instruments required for the absolute determination of the magnetic elements on all convenient occasions on land or on the ice, but each ship was supplied with the necessary apparatus for the continuous record of each of the three elements at stations of winter detention, similar to the apparatus supplied to the Colonial magnetic observatories at Toronto, the Cape of Good Hope, &c. The instruments and apparatus were prepared at the Woolwich office, where also the officers of the expedition were taught and practised in their use by Lieut. Riddell, R.A., who had himself conducted similar observations at Toronto in the winter of 1840.

Although the magnetical records of this ill-fated voyage have perished with its geographical records, there is reason to believe from unmistakable evidence (related by those who were the first to visit Beechey Island after the winter of 1845-1846), not only that the "Erebus" and "Terror" passed that winter there, but that their magnetic apparatus was landed on the island, and employed during the winter months. The records of these observations, however, must have perished with the ships themselves, when in the spring of 1847 the surviving officers and seamen abandoned the ships and sought safety in their boats.

The naval expeditions which were sent by the Admiralty in search of Sir John Franklin's ships were supplied with magnetic instruments prepared in a similar manner at the Woolwich office, and the officers instructed in their use. On the return to England of these expeditions the records of their observations were by the Admiralty transmitted to Woolwich for reduction and publication; and the results have been incorporated in the maps of the *North Polar Magnetic Hemisphere* which are now in course of publication in the Philosophical Transactions, combining with the *South Polar* and *Equatorial* maps, to exhibit a representation of the lines of magnetic declination, inclination, and intensity over the whole surface of the globe corresponding to the epoch 1842–5, attesting the activity of scientific research in our times by the united efforts of individual zeal and Government aid.

Extension of the North American Magnetic Survey from the Rocky Mountains to the Pacific, by Captain R. W. Haig, Royal Artillery.

In 1858 a Commission was appointed for the purpose of determining and marking the boundary line of the 49th parallel of latitude from the Rocky Mountains to the Pacific. Captain Haig, of the Royal Artillery, one of the commissioners, having expressed his readiness to undertake the extension of the North American Magnetic Survey in the localities to be surveyed by the commission, was supplied at the request of the Royal Society with the necessary magnetic instruments prepared at the Kew Observatory. On the completion of the duties of the commission, Capt. Haig returned to England, and presented the account of his magnetic survey to the Royal Society, by whom it was printed in the Philosophical Transactions for 1863.

Magnetic Survey of the East Indian Archipelago, by Capt. Charles M. Elliot, of the Madras Engineers.

In January 1846 Captain Elliot, who had previously filled the post of Superintendent of the Magnetic Observatory established by the Court of Directors of the East India Company at Singapore, was, on the recommendation of the Royal Society, appointed by the Court of Directors to undertake the magnetic survey of the Eastern Archipelago. The details of the execution of this admirable work, completed in 1849, were published in the Philosophical Transactions for 1851, delineating with very satisfactory precision the magnetic lines of declination, inclination, and intensity, extending over 30° of latitude, *i.e.*, from 10° S. to 20° N., and over 50° of longitude, *i.e.*, from 80° E. to 130° E. On the completion of this work, creditable alike to the liberality of the Court of Directors, and to the zeal and ability of Captain Elliot, he was directed to proceed to Madras with a view to his being employed in the general magnetic survey of India. His health, however, which had been much impaired by the previous survey, failed entirely soon after his arrival in India, nor did he long survive.

On Captain Elliot's decease efforts were made to obtain the services of a competent officer to succeed him, and who could be spared from other duties; but these were unsuccessful. In this dilemma the services of the Messrs. Schlagintweit, advantageously known in many branches of physical research in Europe, were strongly recommended by King Frederick William of Prussia, and by Baron Alexander von Humboldt, and being warmly urged by Baron Bunsen, Prussian Minister at the Court of St. James's, were accepted by the Court of Directors.

Having received instruction in the use of our English magnetic instruments at Woolwich, the three brothers, Herman, Adolphe, and Robert, proceeded to India in the autumn of 1854, two of the brothers crossing the chains of the Karakorum and of the Kuenluen, and the third, Adolphe, penetrating to Kashgar, where he was unfortunately killed. The two surviving brothers returned to Europe *viâ* Egypt in the summer of 1857. The magnetic observations of the three brothers comprise 70 stations between Galle (in Ceylon) in 6° 2′ N., and the Karakorum Pass in 35° 47′ N. lat., and between Shikarpore in 68° 52′ E. and Dibrugarth in 94° 58′ E. longitude. The details, accompanied by maps, in which the lines of the magnetic elements are drawn, are given in the first volume of the "Results of a Scientific Mission to India and High Asia." They form a part of the materials incorporated in the *Survey of the Northern Magnetic Hemisphere* about to be presented to the Royal Society.

Pendulum Experiments.

The secretary's letter refers lastly to the belief entertained by the Royal Commission that the Government has not acted without communication with the Council of the Royal Society in other scientific inquiries, and adds that the Commission would be glad to have such a report, or such evidence on such matters, as might aid them in their deliberations as to the most useful relations of the Government with the scientific associations, and especially with the Royal Society.

In replying to this passage of their instructions it is fitting that I should give due prominency to the experiments on *the length of the seconds pendulum in different latitudes*, in which the active co-operation of the British Government and of the Royal Society has subsisted for more than half a century, and has not yet terminated.

It was in 1816 that Mr. Davies Gilbert, then a member of the Board of Longitude, and sitting for the borough of Bodmin in the House of Commons, moved an address to the Crown, praying "that His Majesty would be graciously "pleased to give directions for determining the length of "the pendulum vibrating seconds at the principal stations "of the Trigonometrical Survey of Great Britain."

His Majesty's ministers having requested the assistance of the Royal Society in carrying into effect the object of this address, its prosecution was undertaken by one of the most accomplished members of that Society, Captain Henry Kater, and was completed in 1819, the results being published in the Philosophical Transactions of the same year.

In the summer of 1817, whilst these experiments were in progress, Her Majesty's Government decided on commencing the series of *North Polar voyages* already adverted to; and having consulted the Royal Society in reference to the scientific researches suitable to the occasion, an extension of the experiments on the length of the seconds pendulum to the high latitudes of the Arctic Circle was proposed and approved, suitable apparatus being prepared under Captain Kater's direction. The experiments were conducted at Spitzbergen by the Rev. George Fisher, and at Hare Island and at Melville Island by myself, in the voyages of 1818, 1819, and 1820, the accounts being published in the Philosophical Transactions.

In 1821, on a proposition from myself to the Royal Society and to the Board of Longitude, to extend the series of determinations with Captain Kater's invariable pendulum to stations in the vicinity of the Equator (which was approved and recommended to Her Majesty's Government by the two bodies referred to), the "Pheasant" sloop of war was placed at my disposal; and on the completion of her voyage, which included seven Equatorial stations, the "Griper" sloop of war was commissioned in 1823 expressly for a similar mission to the Arctic Circle, within which the determinations were made at four stations; and the final series in London being completed, a relation of the whole proceedings, Polar and Equatorial, was published in 1825 by Government on the recommendation of the Board of Longitude.

In 1828, at the instance of the Admiralty, and on the recommendation of the Royal Society, the "Chanticleer" sloop of war was commissioned by Captain Henry Foster, F.R.S., to extend the experiments on the length of the seconds pendulum, which had thus been completed in the Northern Hemisphere, to the Southern Hemisphere.

The experiments were made at 10 stations between the Equator and a station in South Shetland, in latitude 62° 56′ S., and at two stations in the Equatorial zone of the Northern Hemisphere. Captain Foster, having been accidentally drowned before the "Chanticleer's" return to England, the account of these experiments was drawn up by the late Francis Baily, Esq., and published at the expense of Government in the 7th vol. of the Transactions of the Royal Astronomical Society. The results of the two series of experiments give for the ellipticity of the earth—

> *Sabine*, 13 stations in the Northern Hemisphere $\frac{1}{288{\cdot}4}$ of the Equatorial diameter.
>
> *Foster*, 12 Equatorial and southern stations $\frac{1}{289{\cdot}5}$ of the Equatorial diameter.

The near accord of the two results appears to leave little doubt of the approximate truth of both.

Satisfactory as appeared the accord in the general results of two such extensive series, it was justly remarked that all the stations in both hemispheres at which the experiments had been made, were either on *islands*, or on the *shores of extensive oceans;* and that it would be desirable, if possible, to compare with these the results of a series of continental stations. The great Trigonometrical Survey of India appearing to present a suitable field for such operations, together with an organization eminently fitted for their successful accomplishment, a communication was made in May 1864, by myself, as President of the Royal Society, to Colonel Walker, superintendent of the Indian Survey. It was responded to by a proposition from that officer of a scheme for the execution of a series of experiments, under selected officers of the Trigonometrical Survey, at not less than 18 stations in India, requiring possibly from four to five years for its execution; the pendulums and clocks to be employed being those which had been used in the earlier series, and which being now in the possession of the Royal Society were available for the purpose. Colonel Walker's proposition having been submitted for consideration to several of the principal Fellows of the Royal Society, regarded as specially conversant with the subject, was communicated, together with letters from them, to the Secretary of State for India. The plan of operation thus proposed, and thus supported, was approved by the Government of India, and its execution was proceeded with.

By a recent letter (August 1870) from Colonel Walker to the Secretary of State for India, a copy of which has been transmitted to the President of the Royal Society, it appears that pendulum experiments have already been made at 20 stations on the main land of India, in a nearly north and south line between 8° 10′ N. and 30° 28′ N., and also at five coast and one insular station between 8° 17′ N. and 22° 33′ N.: and that further operations are in progress, for including in the series stations on three extensive table lands of great height in the Himalaya range, to be contrasted with a station in the plains of the Punjab, and at Kurachi, near the mouth of the Indus.

In addition to this extensive series, including not less than 30 stations in India alone, Colonel Walker has proposed, and the Government of India has approved, the addition of two stations to be observed at on the return route from India to England, viz., at Aden and at the Bitter Lakes.

On the return of the pendulums to England it will be requisite that they should be again vibrated at Kew for the purpose of ascertaining, by comparison with the earlier results at Kew, whether any change may have taken place in their times of vibration during the long period of their employment in India. Colonel Walker also proposes that on the return of the pendulums to England their rates should be ascertained at the Royal Observatory at Greenwich, and as nearly as may be at the identical spot where the original convertible pendulum, constructed by Captain Kater, was employed in a vacuum apparatus by myself in 1830, as recorded in the Philosophical Transactions for 1831.

Foundation of the Meteorological Department of the Board of Trade.

The action of the Royal Society in this matter originated in a letter addressed by the Secretary of the Board of Trade to the President and Council of the Royal Society, on the 3d of June 1854, acquainting them that it was the intention of the Board of Trade, in concurrence with the Treasury, "to submit to Parliament an estimate for an "office for the discussion of the observations on meteo-"rology, which it is proposed to make at sea in all parts of "the globe, in conformity with the recommendation of "the Conference held at Brussels in the preceding year. "Before doing so, however, they are desirous of having "the opinion of the Royal Society as to what are the great "desiderata in meteorology, and as to what forms that "Society consider the best calculated to exhibit the great "atmospheric laws which it may be most desirable to "develope."

The letter from the Board of Trade went on to state that, "as it may possibly happen that observations *on land* "upon an extensive scale may hereafter be made and dis-"cussed in the same office, it is desirable that in framing "the reply such a contingency should be borne in mind "and provided for."

Upon receipt of this communication, the President and Council deemed it advisable, before making a reply, to obtain the opinions of those among their own and their foreign members who were known as distinguished cultivators of meteorological science; as well as of others in foreign countries who either held offices connected with the advancement of meteorology, or had otherwise devoted themselves to that branch of science.

A circular was accordingly addressed to those gentlemen containing a copy of the communication from the Board of Trade, and a request to be favoured with any suggestion that might aid Her Majesty's Government in an undertaking which was obviously one of general concernment.

Replies having been received and submitted to the consideration of a special committee, the draft of a reply from the President and Council of the Royal Society to the Board of Trade was prepared, and being approved, was communicated to the Board on February 22d, 1855. The reply was as follows:—

"Reply of the President and Council of the Royal Society "to an application from the Lords of the Committee "of Privy Council for Trade, on the subject of Marine "Meteorological Observations."—Feb. 22nd, 1855.

[This letter was communicated to the Royal Society in pursuance of a resolution of the Council. The secretary explained that it had been drawn up by the treasurer, Colonel Sabine, and submitted, before final adoption by the Council, to several Fellows of the Society specially conversant with the subjects to which it refers. The letter was addressed to the Secretary of the Lords of the Committee of the Privy Council for Trade.]

Royal Society, Somerset House,
February 22, 1855.

SIR,

In the month of June last the Lords of the Committee of the Privy Council for Trade caused a letter to be addressed to the President and Council of the Royal Society, acquainting them that their Lordships were about to submit to Parliament an estimate for an office for the discussion of the observations on meteorology, to be made at sea in all parts of the globe, in conformity with the recommendation of a conference held at Brussels in 1853; and that they were about to construct a set of forms for the use of that office, in which they proposed to publish from time to time and to circulate such statistical results obtained by means of the observations referred to, as might be considered most desirable by men learned in the science of meteorology, in addition to such other information as might be required for the purposes of navigation.

Before doing so, however, their Lordships were desirous of having the opinion of the Royal Society as to what were the great desiderata in meteorological science; and as to the forms which may be best calculated to exhibit the great atmospheric laws which it may be most desirable to develope.

Their Lordships further state, that as it may possibly happen that observations on land upon an extended scale may hereafter be made and discussed in the same office, it is desirable that the reply of the Royal Society should keep in view and provide for such a contingency.

Deeply impressed with a sense of the magnitude and importance of the work which has been thus undertaken by Her Majesty's Government and confided to the Board of Trade, and fully appreciating the honour of being consulted, and the responsibility of the reply which they are called upon to make; considering also that by including the contingency of *land* observations, the inquiry is, in fact, co-extensive with the requirements of meteorology over all accessible parts of the earth's surface, the President and Council of the Royal Society deemed it advisable, before making their reply, to obtain the opinion of those amongst their foreign members who are known as distinguished cultivators of meteorological science, as well as of others in foreign countries who either hold offices connected with the advancement of meteorology, or have otherwise devoted themselves to this branch of science.

A circular was accordingly addressed to several gentlemen whose names were transmitted to the Board of Trade in June last, containing a copy of the communication from the Board of Trade, and a request to be favoured with any suggestions which might aid Her Majesty's Government in an undertaking which was obviously one of general concernment.

Replies in some degree of detail have been received from five of these gentlemen,* copies of which are herewith transmitted.

The President and Council are glad to avail themselves of this opportunity of expressing their acknowledgments to these gentlemen, and more particularly to Professor Dove, Director of the Meteorological Establishments and Institutions in Prussia, whose zeal for the advancement of meteorology induced him to repair personally to England, and to join himself to the committee by whom the present reply has been prepared. Those who are most familiar with the labours and writings of this eminent meteorologist will best be able to appreciate the value of his co-operation.

The President and Council have considered that the most convenient course to divide their reply under the different heads into which the subject naturally branches. But before they proceed to treat of these, they wish to remark generally that one of the chief impediments to the advancement of meteorology consists in the very slow progress which is made in the transmission from one country to another of the observations and discussions on which, under the fostering aid of different Governments, so much labour is bestowed in Europe and America; and they would therefore recommend that such steps as may appear desirable should be taken by Her Majesty's Government to promote and facilitate the mutual interchange of meteorological publications emanating from the Governments of different countries.

Barometer.

It is known that considerable differences, apparently of a permanent character, are found to exist in the mean barometric pressure in different places; and that the periodical variations in the pressure in different months and seasons, at the same place, and at different places in different parts of the globe, both as respects period and amount, are such that, in extreme cases, the variations have even opposite features, in regard to period, in places situated in the same hemisphere and at equal distances from the equator.

For the purpose of extending our knowledge of the fact of these departures from the state of equilibrium, and of more fully investigating the causes thereof, it is desirable to obtain by means of barometric observations strictly comparable with each other, and extended over all parts of the globe accessible by land or sea, *tables*, showing the mean barometric pressure *in the year, in each month of the year*, and *in the four meteorological seasons*,—on land, at all stations of observation,—and at sea, corresponding to the middle points of spaces bounded by geographical latitudes and longitudes, not far distant from each other.

The manner of forming such tables from the marine observations which are now proposed to be made, by collecting together observations of the same month in separate ledgers, each of which should correspond to a *geographical space* comprised between specified meridians and parallels, and to a *particular month*, is too obvious to require to be further dwelt upon. The distances apart of the meridians and parallels will require to be varied in different parts of the globe, so that the magnitudes of the spaces which they enclose, and for each of which a table will be formed, may be more circumscribed, when the rapidity of the variation of the particular phenomenon to be elucidated is greatest in regard to geographical space. Their magnitude will also necessarily vary with the number of observations which it may be possible to collect in each space, inasmuch as it is well known that there are extensive portions of the ocean which are scarcely ever traversed by ships, whilst other portions may be viewed as the highways of a constant traffic.

The strict comparability of observations made in different ships may perhaps be best assured, by limiting the observations to those made with instruments compared at the Kew Observatory, before and after their employment in particular ships. From the nature of their construction, the barometers with which Her Majesty's navy and the mercantile marine are to be supplied are not very liable to derangement, except from such accidents as would destroy them altogether. Under present arrangements they will all be carefully compared at Kew before they are sent to the Admiralty or to the Board of Trade; and similar arrangements may easily be made by which they may be returned to Kew for re-examination at the expiration of each tour of service. The comparison of barometers, when embarked and in use, with standards, or supposed standards, at ports which the vessels may visit, entails many inconveniences, and is in many respects a far less satisfactory method. The limitation here recommended is not, however, to be understood as applicable in the case of other establishments than Kew, where a special provision may be made for an equally careful and correct examination.

At land stations, in addition to proper measures to assure the correctness of the barometer and consequent comparability of the observations, care should be taken to ascertain, by the best possible means (independently of the barometer itself), the height of the station above the level of the sea at some stated locality. For this purpose the extension of levels for the construction of railroads will often afford facilities.

It may be desirable to indicate some of the localities where the data, which tables such as those which have been spoken of would exhibit, are required for the solution of problems of immediate interest.

1. It is known, that, over the Atlantic Ocean, a low mean annual pressure exists near the equator, and a high pressure at the north and south borders of the torrid zone (23° to 30° north and south latitudes); and it is probable that from similar causes similar phenomena exist over the corresponding latitudes in the Pacific Ocean; the few observations which we possess are in accord with this supposition; but the extent of space covered by the Pacific is large and the observations are few; they may be expected to be greatly increased by the means now contemplated. But it is particularly over the Indian Ocean, both at the equator and at the borders of the torrid zone, that the phenomena of the barometric pressure, not only annual but also monthly, require elucidation by observation. The trade-winds, which would prevail generally round the globe if it were wholly covered by a surface of water, are interrupted by the large continental spaces in Asia and Australia, and give place to the phenomena of monsoons, which are the indirect results of the heating action of the sun's rays on those continental spaces. These are the cause of the displacement of the trade-winds, and substitution of a current flowing in another direction, which occasion the atmospheric phenomena over the Indian Ocean, and on the north and south sides of that ocean, to be different from those in corresponding localities over, and on either side of the equator in the Atlantic Ocean, and (probably generally also) in the Pacific Ocean.

It is important alike to navigation and to general science to know the limits where the phenomena of the trade-winds give place to those of the monsoons; and whether any and what variations take place in those limits in different parts of the year. *The barometric variations are intimately con-*

---

* Dr. Erman of Berlin, Dr. Lamont of Munich, Prof. Kreil of Vienna, Lieut. Maury of Washington, and M. Quetelet of Brussels.

nected with the causes of these variations, and require to be known for their more perfect elucidation.

The importance, indeed, of a full and complete knowledge of the variations which take place in the limits of the trade-winds generally in both hemispheres, at different seasons of the year, has long been recognised. On this account, although the present section is headed "Barometer," it may be well to remark here, that it is desirable that the forms supplied to ships should contain headings, calling for a special record of the latitude and longitude where the trade-wind is first met with, and where it is first found to fail.

2°. The great extent of continental space in Northern Asia causes, by reason of the great heat of the summer and the ascending current produced thereby, a remarkable diminution of atmospheric pressure in the summer months, extending in the north to the Polar Sea, and on the European side as far as Moscow. Towards the east it is known to include the coasts of China and Japan, but the extent of this great diminution of summer pressure beyond the coasts thus named is not known. A determination of the monthly variation of the pressure over the adjacent parts of the Pacific Ocean is therefore a desideratum; and for the same object it is desirable to have a more accurate knowledge than we now possess of the prevailing direction of the wind in different seasons in the vicinity of the coasts of China and Japan.

3°. With reference to regions or districts of increased or diminished *mean annual* pressure, it is known that in certain districts in the temperate and polar zones, such as in the vicinity of Cape Horn extending into the Antarctic Polar Ocean, and in the vicinity of Iceland, the mean annual barometric pressure is *considerably* less than the average pressure on the surface of the globe generally; and that anomalous differences, also of considerable amount, exist in the mean annual pressure in different parts of the Arctic Ocean. These all require special attention, with a view to obtain a more perfect knowledge of the facts, in regard to their amount, geographical extension, and variation with the change of seasons, as well as to the elucidation of their causes.

Dry Air and Aqueous Vapour.

The apparently anomalous variations which have been noticed to exist in the mean annual barometric pressure, and in its distribution in the different seasons and months of the year, are also found to exist in each of the two constituent pressures which conjointly constitute the barometric pressure. In order to study the problems, connected with these departures from a state of equilibrium, under their most simple forms,—and generally for the true understanding of almost all the great laws of atmospheric change,—it is necessary to have a separate knowledge of the two constituents (viz., the pressures of the dry air and of the aqueous vapour) which we are accustomed to measure together by the barometer. This separate knowledge is obtained by means of the hygrometer, which determines the elasticity of the vapour, and leads to the determination of that of the dry air, by enabling us to deduct the elasticity of the vapour from that of the whole barometric pressure. It is therefore extremely desirable that tables, similar to those recommended under the preceding head of the barometer, should be formed at every land station, and over the ocean at the centres of geographical spaces bounded by certain values of latitude and longitude, for the *annual, monthly,* and *season* pressures 1, of the aqueous vapour; and 2, of the dry air: each considered separately. Each of the said geographical spaces will require its appropriate ledger for each of the twelve months.

It may be desirable to notice one or two of the problems connected with extensive and important atmospherical laws which may be materially assisted by such tables.

1°. By the operation of causes which are too well known to require explanation here, the dry air should always have a minimum pressure in the hottest months of the year. But we know that there are places where the contrary prevails, namely, that the pressure of the dry air is greater in summer than in winter. We also know that when comparison is made between places in the same latitude, and having the same (or very nearly the same) differences of temperature in summer and in winter, the differences between the summer and winter pressures of the dry air are found to be subject to many remarkable anomalies. The variations in the pressure of the dry air do not therefore, as might be at first imagined, depend altogether on the differences between the summer and winter temperatures at the places where the variations themselves occur. The increased pressure in the hottest months appears rather to point to the existence of an overflow of air in the higher regions of the atmosphere from *lateral sources,* the statical pressure at the base of the column being increased by the augmentation of the superincumbent mass of air arising from an influx in the upper portion. Such lateral sources may well be supposed to be due to *excessive ascensional currents* caused by *excessive summer heats* in certain places of the globe (as, for example, in Central Asia). Now the lateral overflow from such sources, traversing in the shape of currents the higher regions of the atmosphere and encountering the well-known general current flowing from the equator towards the pole, has been recently assigned with considerable probability (derived from its correspondence with many otherwise anomalous phenomena already known, and which all receive an explanation from such supposition) to be the original source or primary cause of the *rotating storms* or *cyclones,* so well known in the West Indies and in China under the names of hurricanes and typhoons. A single illustration may be desirable. Let it be supposed that such an excessive ascensional current exists over the greatly heated parts of Asia and Africa in the northern tropical zone,—giving rise, in the continuation of the same zone over the Atlantic Ocean, to a lateral current in the upper regions; this would then be a current prevailing in those regions from east to west: and it would encounter over the Atlantic Ocean the well-known upper current proceeding from the equator towards the pole, which is a current from the south-west. An easterly current impinging on a south-west current may give rise, by well-known laws, to a rotatory motion in the atmosphere, of which the direction may be the same as that which characterises the cyclones of the Northern Hemisphere. To test the accuracy of this explanation, we desire to be acquainted with the variations which the *mean pressure of the dry air undergoes in the different seasons* in the part of the globe where, according to this explanation, considerable variations having particular characters ought to be found.

2°. We have named one of the explanations which have been recently offered of the primary cause of the northern cyclones. Another mode of explanation has been proposed, by assuming the condensation of large quantities of vapour, and the consequent influx of air to supply the place. In such case the phenomena are to be tested in considerable measure by the variations which the *other constituent* of the barometric pressure, namely, the *aqueous vapour,* undergoes.

3°. The surface of sea in the Southern Hemisphere *much* exceeds that in the Northern Hemisphere. It is therefore probable that at the season when the sun is over the Southern Hemisphere, evaporation over the whole surface of the globe is more considerable than in the opposite season when the sun is over the Northern Hemisphere. Supposing the pressure of the dry air to be a constant, the difference of evaporation in the two seasons may thus produce for the whole globe an *annual barometric variation,* the aggregate barometric pressure over the *whole* surface being highest during the northern winter. The separation of the barometric pressure into its two constituent pressures would give direct and conclusive evidence of the cause to which such a barometric variation should be ascribed. It would also follow, that evaporation being greatest in the south, and condensation greatest in the north, the water which proceeds from south to north in a state of vapour would have to return to the south in a liquid state, and might possibly exert some discernible influence on the currents of the ocean. The tests by which the truth of the suppositions thus advanced may be determined are the variations of the meteorological elements in different seasons and months, determined by methods and instruments strictly comparable with each other, and arranged in such tables as have been suggested. A still more direct test would indeed be furnished by the fact (if it could be ascertained), that the quantity of rain which falls in the Northern is greater than that which falls in the Southern Hemisphere; and by examining its distribution into the different months and seasons of its occurrence. Data for such conclusions are as yet very insufficient; they should always, however, form a part of the record at all land stations where registers are kept.

In order that all observations of the elasticity of the aqueous vapour may be strictly comparable, it is desirable that all should be computed by the same tables; those founded upon the experiments of MM. Regnault and Magnus may be most suitably recommended for this purpose, not only on their general merits, but also as being likely to be most generally adopted by observers in other countries.

Temperature of the Air.

Tables of the mean temperature of the air in the year, and in the different months and seasons of the year, at above 1,000 stations on the globe, have recently been computed by Professor Dove, and published under the auspices of the Royal Academy of Sciences at Berlin. This work—which is a true model of the method in which a great body of meteorological facts, collected by different observers and at different times, should be brought together and coordinated—has conducted, as is well known, to conclusions of very considerable importance in their bearing on climatology, and on the general laws of the distribution of heat on the surface of the globe. These tables have, however, been formed exclusively from observations made *on land*. For the completion of this great work of physical geography, there is yet wanting a similar investigation for the *oceanic* portion; and this we may hopefully anticipate as likely to be now accomplished by means of the marine observations about to be undertaken. In the case of the temperature of the air, as in that of the atmospheric pressure previously adverted to, the centres of geographical spaces bounded by certain latitudes and longitudes will form points of concentration for observations, which may be made within those spaces, not only by the same but also by different ships; provided that the system be steadily maintained of employing only instruments which shall have been examined, and their intercomparability ascertained, by a competent and responsible authority; and provided that no observations be used but those in which careful attention shall have been given to the precautions which it will be necessary to adopt, for the purpose of obtaining the correct knowledge of the temperature of the external air, amidst the many disturbing influences from heat and moisture so difficult to escape on board ship. In this respect additional precautions must be used if *night observations* are to be required, since the ordinary difficulties are necessarily much enhanced by the employment of artificial light. Amongst the instructions which will be required, perhaps there will be none which will need to be more carefully drawn than those for obtaining the correct temperature of the external air under the continually varying circumstances that present themselves on board ship.

In regard to *land stations* Professor Dove's tables have shown that data are still pressingly required from the British North American possessions intermediate between the stations of the Arctic Expeditions and those of the United States; and that the deficiency extends across the whole North American continent in those latitudes from the Atlantic to the Pacific. Professor Dove has also indicated as desiderata, observations at the British military stations in the Mediterranean (Gibraltar, Malta, and Corfu), and around the coasts of Australia and New Zealand: also that *hourly* observations continued for at least one year, are particularly required at some one station in the West Indies to supply the diurnal corrections for existing observations.

Whilst the study of the distribution of heat at the surface of the globe has thus been making progress, in respect to the *mean annual temperature* in different places, and to its *periodical variations* in different parts of the year at the same place, the attention of physical geographers has recently been directed (and with great promise of important results to the material interests of men as well as to general science) to the causes of those fluctuations in the temperature, or departures from its mean or normal state at the same place and at the same period of the year, which have received the name of "non-periodic variations." It is known that these frequently affect extensive portions of the globe at the same time; and are generally, if not always, accompanied by a fluctuation of an opposite character, prevailing at the same time in some adjoining but distant region; so that by the comparison of synchronous observations a progression is traceable, from a locality of maximum increased heat in one region, to one of maximum diminished heat in another region. For the elucidation of the non-periodic variations even *monthly* means are insufficient; and the necessity has been felt of computing the mean temperatures for periods of much shorter duration. The meteorological institutions of those of the European States which have taken the foremost part in the prosecution of meteorology have in consequence adopted *five-day means* as the most suitable intermediate gradation between daily and monthly means; and as an evidence of the conviction which is entertained of the value of the conclusions to which this investigation is likely to lead, it has been considered worth while to undertake the prodigious labour of calculating the five-day means of the most reliable existing observations during a century past. This work is already far advanced; and it cannot be too strongly recommended, that at all fixed stations, where observations shall hereafter be made with sufficient care to be worth recording, five-day means may invariably be added to the daily, monthly, and annual means into which the observations are usually collected. The five-day means should always commence with January 1, for the purpose of preserving the uniformity at different stations, which is essential for comparison: in leap years, the period which includes the 29th of February will be of six days.

In treating climatology as a *science*, it is desirable that some correct and convenient mode should be adopted for computing and expressing the *comparative variability* to which the temperature in different parts of the globe, and in different parts of the year in the same place, is subject from non-periodic causes. The *probable variability* computed on the same principle as the *probable error* of each of a number of independent observations has recently been suggested as furnishing an index "of the probable daily non-periodic variation" at the different seasons of the year; and its use in this respect has been exemplified by calculations of the "index" from the five-day means of twelve years of observations at Toronto, in Canada (Phil. Trans., 1853, Art. V.). An index of this description is of course of absolute and general application, supplying the means of comparing the probable variability of the temperature in different seasons at *different places* (where the same method of computation is adopted) as well as at the *same place*. It is desirable that this (or some preferable method if such can be devised for obtaining the same object) should be adopted by those who may desire to make their observations practically useful for sanitary or agricultural purposes, or for any of the great variety of objects for which climatic peculiarities are required to be known. Having these three data, viz., the mean annual temperature,—its periodical changes in respect to days, months, and seasons,—and the measure of its liability to non-periodic (or what would commonly be called, irregular) variations,—we may consider that we possess as complete a representation of the climate of any particular place (so far as temperature is concerned), as the present state of our knowledge permits.

It is obvious that much of what has been said under this article is more applicable to land than to sea observations; but the letter of the Board of Trade, to which this is a reply, requests that both should be contemplated.

Temperature of the Sea, and Investigations regarding Currents.

It is unnecessary to dwell on the practical importance to *navigation* of a correct knowledge of the currents of the ocean; their direction, extent, velocity, and the temperature of the surface-water relatively to the ordinary ocean temperature in the same latitude; together with the variations in all these respects which currents experience in different parts of the year, and in different parts of their course. As the information on these points which may be expected to follow from the measures adopted by the Board of Trade must necessarily depend in great degree on the *intelligence*, as well as the *interest* taken in them by the observers, it is desirable that the instructions to be supplied with the meteorological instruments should contain a brief summary of what is already known in regard to the principal oceanic currents; accompanied by charts on which their supposed limits in different seasons, and the variations in those limits which may have been observed in particular years, may be indicated, with notices of the particularities of the temperature of the surface-water by which the presence of the current may be recognised. Forms will also be required for use in such localities, in which the surface temperatures may be recorded at hourly or half-hourly intervals, with the corresponding geographical positions of the ship, as they may be best inferred from observation and reckoning. For such localities also it will be necessary that the tables into which the observations of different ships at different seasons are collected should have their bounding lines of latitude and longitude brought nearer together than may be required for the ocean at large.

In looking forward to the results which are likely to be obtained by the contemplated marine observations, it is reasonable that those which may bear practically on the interests of navigation should occupy the first place; but, on the other hand, it would not be easy to over-estimate the advantages to physical geography, of general tables of the surface temperature of the ocean in the different months of the year, exhibiting, as they would do, its normal and its abnormal states, the mean temperature of the different parallels, and the deviations therefrom, whether permanent, periodical, or occasional. The knowledge which such tables would convey is essentially required for the study of climatology *as a science*.

The degree in which climatic variations extending over large portions of the earth's surface may be influenced by the variable phenomena of oceanic currents in different years may perhaps be illustrated by circumstances of known occurrence in the vicinity of our own coasts. The admirable researches of Major Rennell have shown that, in ordinary years, the warm water of the great current known by the name of the Gulf-stream is not found to the east of the meridian of the Azores, the sea being of ordinary ocean temperature for its latitude, at all seasons and in every direction, in the great space comprised between the Azores and the coasts of Europe and North Africa; but Major Rennell has also shown that on two occasions, viz., in 1776 and in 1821–1822, the warm water by which the Gulf-stream is characterised throughout its whole course (*being several degrees* above the ordinary ocean temperature in the same latitude), was found to extend across this great expanse of ocean, and in 1776 (in particular) was traced (by Dr. Franklin) quite home to the coast of Europe. The presence of a body of unusually heated water, extending for several hundred miles both in latitude and in longitude, and continuing for several weeks, at a season of the year when the prevailing winds blow from that quarter on the coasts of England and France, can scarcely be imagined to be without a considerable influence on the relations of temperature and moisture in those countries. In accordance with this supposition, we find in the meteorological journals of the more recent period (which are more easily accessible), that the state of the weather in November and December 1821 and January 1822 was so unusual in the southern parts of Great Britain and in France as to have excited general observation; we find it characterised as "most extraordinarily hot, damp, stormy, and oppressive," that "the gales from the W. and S.W. were almost without intermission," "the fall of rain was excessive," and "the barometer lower than it had ever been known for 35 years before."

There can be little doubt that Major Rennell was right in ascribing the unusual extension of the Gulf-stream in particular years to its greater initial velocity, occasioned by a more than ordinary difference in the levels of the Gulf of Mexico and of the Atlantic in the preceding summer. An unusual height of the Gulf of Mexico at the head of the stream, or an unusual velocity of the stream at its outset in the Strait of Florida, are facts which may admit of being recognised by properly directed attention; and as these must precede, by many weeks, the arrival of the warm water of the stream at above 3,000 miles distance from its outset, and the climatic effects thence resulting, it might be possible to anticipate the occurrence of such unusual seasons upon our coasts.

Much, indeed, may undoubtedly be done towards the increase of our partial acquaintance with the phenomena of the Gulf-stream, and of its counter currents, by the collection and co-ordination of observations made by casual passages of ships in different years and different seasons across different parts of its course; but for that full and complete knowledge of all its particulars, which should meet the maritime and scientific requirements of the period in which we live, we must await the disposition of Government to accede to the recommendation, so frequently made to them by the most eminent hydrographical authorities, of a specific survey of the stream by vessels employed for that special service. What has been recently accomplished by the Government of the United States in this respect shows both the importance of the inquiry and the great extent of the research, and lends great weight to the proposition, which has been made to Her Majesty's Government on the part of the United States, for a joint survey of the whole stream by vessels of the two countries. The establishment of an office under the Board of Trade specially charged with the reduction and co-ordination of such data may materially facilitate such an undertaking.

Storms or Gales.

It is much to be desired, both for the purposes of navigation and for those of general science, that the captains of Her Majesty's ships and masters of merchant vessels should be correctly and thoroughly instructed in the methods of distinguishing *in all cases* between the rotatory storms or gales, which are properly called *cyclones*, and gales of a more ordinary character, but which are frequently accompanied by a veering of the wind, which, under certain circumstances, might easily be confounded with the phenomena of cyclones, though due to a very different cause. It is recommended, therefore, that the instructions, proposed to be given to ships supplied with meteorological instruments, should contain clear and simple directions for distinguishing *in all cases* and *under all circumstances* between these two kinds of storms, and that the forms to be issued for recording the meteorological phenomena during great atmospheric disturbances should comprehend a notice of all the particulars which are required for forming a correct judgment in this respect.

Thunder-storms.

It is known that in the high latitudes of the Northern and Southern Hemispheres thunder-storms are almost wholly unknown, and it is believed that they are of very rare occurrence over the ocean in the middle latitudes when distant from continents. By a suitable classification and arrangement of the documents which will be henceforward received by the Board of Trade, statistical tables may in process of time be formed, showing the comparative frequency of these phenomena in different parts of the ocean, and in different months of the year.

It is known that there are localities on the globe where, during certain months of the year, thunder-storms may be considered as a periodical phenomenon of daily occurrence. In the Port Royal Mountains in Jamaica, for example, thunder-storms are said to take place *daily* about the hour of noon from the middle of November to the middle of April. It is much to be desired that a full and precise account of such thunder-storms, and of the circumstances in which they appear to originate, should be obtained.

In recording the phenomena of thunder and lightning it is desirable to state the duration of the interval between the flashes of lightning and the thunder which follows. This may be done by means of a seconds-hand watch, by which the time of the apparition of the flash, and of the commencement (and of the conclusion also) of the thunder may be noted. The interval between the flash and the commencement of the thunder has been known to vary in different cases, from less than a single second to between 40 and 50 seconds, and even on very rare occasions to exceed 50 seconds. The two forms of ordinary lightning, viz., zigzag (or forked) lightning, and sheet lightning, should always be distinguished apart; and particular attention should be given both to the observation and to the record, in the rare cases when zigzag lightning either bifurcates or returns upwards. A special notice should not fail to be made when thunder and lightning, or either separately, occur in a perfectly cloudless sky. When globular lightning (balls of fire) are seen, a particular record should be made of all the attendant circumstances. These phenomena are known to be of the nature of lightning, from the injury they have occasioned in ships and buildings that have been struck by them; but they differ from ordinary lightning not only by their globular shape, but by the length of time they continue visible, and by their slow motion. They are said to occur sometimes without the usual accompaniments of a storm, and even with a perfectly serene sky. Conductors are now so universally employed in ships that it may seem almost superfluous to remark that, should a ship be struck by lightning, the most circumstantial account will be desirable of the course which the lightning took, and of the injuries it occasioned; or to remind the seaman that it is always prudent, after such an accident has befallen a ship, to distrust her compasses until it has been ascertained that their direction has not been altered. Accidents occurring *on land* from lightning will, of course, receive the fullest attention from meterologists who may be within convenient distance of the spot.

Auroras and Falling Stars.

Auroras are of such rare occurrence in seas frequented by ships engaged in commerce that it may seem superfluous to give any particular directions for their observation *at sea*; and land observatories are already abundantly furnished with such. It is, of course, desirable that the meteorological reports received from ships should always contain a notice of the time and place where auroras may be seen, and of any remarkable features that may attract attention.

The letter from Professor Heis, which is one of the foreign communications annexed, indicates the principal points to be attended to in the instructions which it may be desirable to draw up for the observation of "falling stars." For directions concerning halos and parhelia, a paper by Monsieur Bravais, in the "Annuaire Météorologique de la France" for 1851, contains suggestions which will be found of much value.

Charts of the Magnetic Variation.

Although the variation of the compass does not belong in strictness to the domain of meteorology, it has been included, with great propriety, amongst the subjects treated of by the Brussels Conference, and should not therefore be omitted here. It is scarcely necessary to remark, that whatever may have been the practice in times past, when the phenomena of the earth's magnetism were less understood than at present, it should in future be regarded as indispensable, that variation-charts should always be constructed for a *particular epoch*, and that *all parts* of the chart should show *the variation corresponding to the epoch for which it is constructed*. Such charts should also have, either engraved on the face or attached in some convenient manner, a table showing the approximate annual rate of the secular change of the variation in the different latitudes and longitudes comprised: so that, by means of this table, the variation taken from the chart for any particular latitude and longitude may be corrected to the year for which it is required, if that should happen to be different from the epoch for which the chart is constructed.

A valuable service would be rendered to this very important branch of hydrography, if, under the authority of the new department of the Board of Trade, variation-charts for the North and South Atlantic Oceans, for the North and South Pacific Oceans, for the Indian Ocean, and for any other localities in which the requirements of navigation might call for them, were published at *stated intervals*, corrected for the secular change that had taken place since the preceding publication. Materials would be furnished for this purpose by the observations which are now intended to be made, supposing them to be collected and suitably arranged with proper references to date and to geographical position, and to the original reports in which the results and the data on which they were founded were communicated. By means of these observations the tables of approximate correction for secular change might also be altered from time to time as occasion should require, since the rate of secular change itself is not constant.

All observed variations, communicated or employed as data upon which variation-charts may be either constructed or corrected, should be accompanied by other observational data (the nature of which ought now to be well understood), for correcting the observed variation for the error of the compass occasioned by the ship's iron. It is also strongly recommended that no observations be received as data for the formation or correction of variation-charts, but such as are accompanied by a detailed statement of the principal elements both of observation and of calculation. Proper forms should be supplied for this purpose; or, what is still better, books of blank forms may be supplied, in which the observations themselves may be entered, and the calculations performed by which the results are obtained. Such sets of blank forms would be found extremely useful both for the variation of the needle and for the chronometrical longitude, as well as for lunar observations, if the practice of lunar observations be not, as there is too much reason to fear it is, almost wholly discontinued). By preparing and issuing books of blank forms suitable for these purposes, and by requesting their return in accompaniment with the other reports to be transmitted to the Board of Trade at the conclusion of a voyage, the groundwork would be laid for the attainment of greatly improved habits of accuracy in practical navigation in the British mercantile marine.

The President and Council are aware that they have not exhausted the subject of this reply in what they have thus directed me to address to you; but they think that perhaps they have noticed as many points as may be desirable for *present* attention, and they desire me to add that they will be at all times ready to resume the consideration if required, and to supply any further suggestions which may appear likely to be useful.

I have, &c.
W. SHARPEY,
Sec. R.S

To the Secretary of the Lords of the Committee
of Privy Council for Trade.

The Meteorological Department of the Board of Trade was originally constituted under the authority of Mr. Cardwell, and the late Admiral FitzRoy was appointed as its head. The instructions under which the department was to prosecute its labours were based on the report received from the Royal Society. The object to be steadily kept in view was the collection, and subsequent discussion, of facts and observations made at sea, too numerous to be collected and discussed by private persons; and the publication, in a form available to seamen, of such results as might be immediately useful, was regarded as the primary and principal function of the office. The prognostication of weather did not form a part of the duties of the office, as originally constituted. Progressively, however, Admiral FitzRoy became more and more impressed with a sense of the practical importance of such prognostications, which were communicated by telegraph to the principal ports of the United Kingdom. The attention of himself and his department was thus gradually diverted from the objects originally recommended to him; and at length, finding the accumulation of ocean statistics increase beyond the divided powers of his office to deal with, he felt himself justified in ceasing to accumulate further contributions of meteorological observations made at sea.

Under these circumstances the Board of Trade, on Admiral FitzRoy's decease, adopted the course of re-opening the communication with the Royal Society by a letter dated May 26th, 1865, referring to the points touched upon in their earlier communication of February 22d, 1855, and requesting "any observations or suggestions which the "President and Council of the Royal Society may be "willing to favour them, on the constitution and objects "of the department, and the manner in which those "objects may be most effectually attained." This letter (dated May 26th, 1865), with the reply (dated June 15th, 1865), and a subsequent letter from the Secretary of the Board of Trade (dated October 24th, 1865), and the reply (dated November 2d, 1865), are subjoined:—

CORRESPONDENCE between the BOARD OF TRADE and the ROYAL SOCIETY relative to the METEOROLOGICAL OFFICE.

Mr. Farrer to the President	-	May 26th, 1865.
Reply - - -	-	June 15th, 1865.
Mr. Farrer to the President	-	October 24th, 1865.
Reply - - -	-	November 2d, 1865.

"Board of Trade, Whitehall,
SIR, May 26, 1865.

"I AM directed by the Lords of the Committee of Privy Council for Trade, on the occasion of the vacancy in the office of Chief of their Meteorological Department, caused by the untimely death of Admiral FitzRoy, to request you to be so good as to bring under the notice of the President and Council of the Royal Society the correspondence which took place between that society and this office, at the time of the institution of the Meteorological Department as a branch of this office; and particularly your letter of the 22d February 1855, in reply to that from this office of the 3d of June 1854, in which, when about to institute the department, my Lords had desired the opinion of the Royal Society as to what were the great desiderata in Meteorological Science. The recommendations of the Royal Society conveyed in your letter of the 22d of February 1855, were adopted as the basis of the proceedings of the Meteorological Department; instruments were provided, logs were prepared, furnished, and returned to the office, and some progress was made in carrying into effect the original programme.

"But in 1859 or 1860, the French Government having adopted a system of telegraphing and publishing the actual state of weather from one place to another, co-operation in which was urged on the Board of Trade by a Committee of the British Association and by Admiral FitzRoy, my Lords gave their sanction to what was proposed, and thenceforward a considerable part of the vote previously applied to obtaining and digesting observations was diverted to these telegrams. In 1861 Admiral FitzRoy grafted on this system of telegraphic communication a system of forecasting the weather, the forecasts being published in the daily papers, and, on occasions of anticipated storms, the giving of special warnings, communicated by telegraph to the different ports, and there made known by hoisting certain signals. The whole, or almost the whole, of the funds originally voted for the purpose of observations were thus diverted from their original scientific object to an object deemed more immediately practical.

"In 1863, on the occasion of an increased estimate for the purpose of these forecasts, it was determined to compare the forecasts and the warnings with the actual results.

"As regards the daily forecasts, the daily reports of weather published by Admiral FitzRoy afforded, and still afford, ample means of checking them.

"As regards the storm warnings, detailed reports were called for from the places to which the warnings were sent. The results of these comparisons for certain periods were tabulated and laid before Parliament in a paper, copy of which is annexed. The data for continuing the return are still kept, and, if it were thought right to incur the expense, it could be continued at any time.

"My Lords at the same time addressed a further letter, dated 27th February 1863, asking the opinion of the Royal Society as to the course then being pursued by Admiral FitzRoy, and were favoured in reply by your letter of the 27th March 1863.

"The vacancy in the Meteorological Department, occasioned by the death of Admiral FitzRoy, has seemed to my Lords to present a fitting opportunity to review the past proceedings and present state of the department; and with this view they are desirous of receiving any observations or suggestions, with which the President and Council of the Royal Society may be willing to favour them, on the constitution and objects of the department, and the mode in which those objects may be most effectually attained.

"The points on which the Board of Trade especially desire the opinion of the Royal Society are the following:

"1. Are the objects specified in the Royal Society's letter of the 22nd February 1855, still as important for the interests of science and navigation as they were then considered?

"2. To what extent have any of these objects been answered by what has already been done by the Meteorological department?

"3. What steps should be taken for making use of any observations already collected, or any compilations already made by the Department?

"4. Is it desirable to make any, and what, further observations on any, and which, of the subjects mentioned in the Royal Society's letter of 22nd February 1855?

"5. What is the nature of the basis on which the system of daily forecasts and storm warnings established by Admiral FitzRoy rests? In other words, are they founded on scientific principles, so that they, or either of them, can be carried on satisfactorily notwithstanding Admiral FitzRoy's decease?

"6. If they, or either of them, can be carried on satisfactorily, can the Royal Society suggest any improvement in the form and manner of doing it?

"7. Is it desirable to continue down to the present time the tables of results corresponding to the forecasts and storm warnings which were made out for certain periods in the year 1863, and were presented to Parliament in April 1864 (Parliamentary Paper, No. 200, Session 1864, inclosed)? The materials for doing this exist in the office and only require clerical labour.

"8. Assuming it to be desirable to continue the publication of the daily reports of weather received from various stations, can the Royal Society make any suggestions as to the extent to which it should be carried, and the form in which it should be done?

"9. Have the Royal Society any general suggestions to make as to the mode, place, or establishment in, at, or by which the duties of the Meteorological Department can best be performed?

"With respect to these heads of inquiry, my Lords desire to observe, in the first place, that they understand that the Admiralty are willing to undertake, and to place in the hands of their hydrographer, all those observations which can properly be made use of in framing charts for purposes of navigation, but not those which relate to meteorology proper.

"Secondly. That the Board of Trade will gladly place the knowledge and services of Mr. Babington, Admiral FitzRoy's second, at the disposal of the Royal Society, for the purpose of the above inquiries, and will also give them any help, clerical or otherwise, which the Royal Society may require, and which the Board of Trade may be able to give.

"I have, &c.
"T. H. FARRER.

"The President of the Royal Society."

The President, on the part of the Committee appointed to consider the letter from Mr. Farrer of the Board of Trade of the 26th of May, reported that the Committee had agreed upon the draft of a reply which they recommended as suitable to be returned to the Board of Trade by the President and Council, which was read as follows:—

"SIR,

"IN replying to your letter of the 26th of May, the President and Council think it may be desirable to advert in the first instance to that which has constituted the chief occupation of Admiral FitzRoy's department in the last four or five years, viz., the systematic forecasting of the weather by means of telegrams received from stations comprised within a certain limited area; and, on occasions of anticipated storms, the giving special warnings conveyed by telegraph to the different ports in the United Kingdom, and there made known by hoisting certain signals.

"The system of forecasting which Admiral FitzRoy instituted and pursued has been expressly described by himself as 'an experimental process,' based on the knowledge conveyed by telegraph of the actual state of the winds and weather and other meteorological phenomena within a specified area, and on a comparison of these with the telegrams of the preceding days, so as to obtain inferences as to the probable changes in the succeeding days. The proper test of the efficiency and usefulness of such a system of cautionary signals at the different ports is to be sought in the *measure of success which it appears to have attained;* always remembering that the system under consideration can only be regarded as in its infancy, and that, if continued, its improvement, and consequently its importance, may be expected to be progressive from year to year. In Admiral FitzRoy's report to the Board of Trade in May 1862, the opinions of the shipmasters at several ports in regard to the practical value which they attached to the storm-signals were given at length. Of the 56 replies published in the appendix of that report, 46 were decidedly favourable, 3 decidedly unfavourable, and 7 expressing no decided opinion. A statement so favourable on the whole, obtained so very shortly after the system had been first brought into operation, must surely be considered to have fully justified the Board of Trade in directing its further prosecution.

"The return to the House of Commons, dated April 13th, 1864, a copy of which accompanied your letter, presents a comparison of the probable force of the wind as indicated by the signals in the year commencing April 1st, 1863, and terminating March 31st, 1864, and its actual state, as reported in the three days following the exhibition of the signals; and Mr. Babington has since been so obliging as to communicate in manuscript a return having the same object in view for the year April 1st, 1864, to March 31st, 1865.

"From the first of these documents, the President and Council learn (in p. 7) that the whole number of signals which were hoisted at different places, and of which reports were received, between April 1, 1863, and March 31, 1864, amounted to 2,288; of these the number which proved correct in respect to the *force* of the wind equalling or exceeding 'a fresh gale,' was 1,284; in 462 cases the stations were reached by the gale (or a still stronger wind blew) before the signal was hoisted; and in 726 within forty-eight hours after the signal was hoisted. Hence we may conclude that (omitting the 96 cases in which the gale occurred between 48 and 72 hours after the signal was hoisted) 1,188 signals, or more than half the whole number of 2,288, were justified by the state of the weather, either when the telegraphic message reached the station, or within forty-eight hours afterwards.

"With respect to *direction* of wind in a gale indicated by signal, the 'warnings' are reported to have been much less frequent. Of the 402 signals indicating direction as well as force, 271 agreed, and 131 did not agree with the real direction of the wind; being a proportion of about two correct to one incorrect.

"The manuscript with which Mr. Babington has favoured the Council since the receipt of your letter of May 26, 1865, contains a summary of the cautionary signals between April 1, 1864, and March 31, 1865, with notes stating their success or failure. From these it appears that signals were hoisted on 40 days in the course of the year, 29 of which appear to have been justified by the event, 8 to have been failures either in respect to force or direction, and 3 were late, the gale having already commenced. There are also 5 cases in which it is admitted that signals might have been made with advantage when none were sent.

"It seems not unreasonable to attribute to increased experience the marked improvement of these results upon those of the preceding year, and to anticipate still further improvement.

"The method adopted in preparing the storm-warnings has been very ably and lucidly explained by Mr. Babington in a paper dated May 11, 1865, presented by him to Mr. Farrer, by whom a copy has been sent to the President and Council. Possibly it may be viewed as the best arrangement that this branch of the duties of the office should continue as at present under the direction of Mr Babington, by whom it has been virtually carried on for several months past.

"On the subject of storms of a cyclonic character originating in the British Islands or in their vicinity, the interest of which was adverted to in the reply from the Royal Society to the Board of Trade, March 27, 1863, reference has been made to Mr. Babington for such further information as may have been subsequently obtained. His reply to General Sabine is as follows:—

"'I can quite confirm your impression respecting Admiral FitzRoy's belief in the evidence of the existence of small cyclonic storms in England itself, originating in or near our islands, and generated in the brushing against each other of the N.E. and S.W. currents; and in reply to your question I beg to say that I believe there is satisfactory evidence of the existence of such storms; but that these small storms are not very frequent—three or four in a year perhaps, and that they are, I think, more common in summer than in winter, although usually of less violence. The *direction* of their motion is certainly almost invariably towards some point between N.N.E. and E.S.E. With regard to the rapidity of their motion, I scarcely feel able to express an opinion; but at the ordinary rate of progression it takes such a storm about 48 hours to pass from Ireland to the Baltic. Not unfrequently, however, they appear to die out (as it were) before travelling so far.'

"The existence of such storms in our islands is a fact in meteorological science of considerable interest, for which we are indebted to the researches instituted and carried on by Admiral FitzRoy's department. Though not of very frequent occurrence, they constitute a class of phenomena well suited for telegraphic advertisement, especially on our eastern and north-eastern coasts. It might perhaps be practically desirable to indicate them by a special signal, distinguishing them from storms which have a more uniform direction. But however this may be, it seems to be desirable that the occurrence of such storms and their attendant phenomena, as obtainable at the time, should be carefully recorded, with a view to the records being ultimately put together in elucidation of a branch of the meteorology of our islands which has hitherto been but imperfectly examined.

"We proceed to notice the points on which we are informed that the Board of Trade especially desire the opinion of the Royal Society; and particularly the inquiry whether the objects specified in the Royal Society's letter of the 22nd of February 1855 are still viewed as of the same importance for the interests of science and navigation as they were then considered.

"The most prominent amongst these objects was the collection and co-ordination of meteorological observations made at sea, including such as are required to form a correct knowledge of the currents of the ocean, their direction, extent, velocity, and the temperature of the surface-water relatively to the ordinary ocean temperature in the same latitude; together with the variations in all these respects which currents experience in different parts of the year and in different parts of their course. These—as well as the facts connected with the great barometric elevations and depressions which we know to exist in several oceanic localities, and their influence on circumstances affecting navigation—were noticed as inquiries well deserving the attention of a country possessing such extensive maritime facilities and interests as ours, and as forming a suitable contribution on our part to the general system of meteorological inquiry which had been adopted by the principal continental states in Europe and America.

"We have learnt from Mr. Babington that much was done by Admiral FitzRoy in the three or four years succeeding the establishment of his office (and before the subject of storm-warnings had engrossed the greater part of his consideration), in directing the attention of many of the commanders of our merchant ships to the collection of suitable data, and in improving their habits of observation and of record. The logs of such vessels form at present a large collection of documents existing in the office of the Board of Trade, partially examined, and their contents partially classified. The President and Council are glad to learn by your letter that the further prosecution of this great and important branch of Hydrography is about to be placed in the hands of the distinguished officer who now presides over the Hydrographic Department of the Admiralty; to whose duties it appears indeed most appropriately to belong, and to whose office no doubt the documents already collected will be transferred and made available for public purposes.

"There remain, therefore, to be noticed solely the considerations which relate to 'Meteorology Proper,' *i.e.*, to the Land Meteorology of the British Islands. We find that the principal States of the European Continent have almost without exception formed establishments for the collection and publication periodically of the meteorology of their respective countries. The arrangements consist usually of a central office, at which instruments and instructions are provided for a number of stations, greater or less, according to the area which they represent; at which stations observations are made and transmitted to the central office, where the results of all are reduced, co-ordinated, and published. The small extent of the area comprised by the British Islands, in comparison with the territories of many of the European States, may require *fewer* stations; but in a matter now so generally attended to and provided for it seems scarcely fitting that our country should be behind others. There is, moreover, a peculiarity in the meteorological position of the British Islands in respect to Europe generally as its north-western outpost, in consequence of which an especial duty appears to devolve upon us. M. Matteucci, in a very recent publication, has already made the important remark that extensive atmospheric disturbances which first invade Ireland and England are those which, in winter more especially, extend to and pass the Alps (although somewhat retarded by them), and spread over Italy: and thus that, though receiving telegrams announcing storms taking place in the North of Europe, in Germany, on the western coasts of France, and on those of Spain, he finds that it has in fact been most especially in the case of announcements from England that storms so telegraphed have actually reached Italy, and been found to correspond with the accounts subsequently received from Italian Mediterranean ports.

"A few stations,—say six, distributed at nearly equal distances in a meridional direction from the south of England to the north of Scotland, furnished with *self-recording* instruments supplied from and duly verified at one of the stations regarded as a central station, and exhibiting a *continuous* record of the temperature, pressure, electric and hygrometric state of the atmosphere, and of the force and direction of the wind—might perhaps be sufficient to supply authoritative knowledge of those peculiarities in the meteorology of our country which would be viewed as of the most importance to other countries, and would at the same time form authentic points of reference for the use of our own meteorologists. The scientific progress of meteorology from this time forward requires indeed such continuous records, first, for the sake of the knowledge which they alone can effectively supply, and next, for comparison with the results of independent observation not continuous. The actual photograms, or other mechanical representations, transmitted weekly by post to the central station would constitute a lithographed page for each day in the year, comprehending the phenomena at all the six stations, each separate curve admitting of exact measurement from its own base-line, the precise value of which might in every case be specified.

"The President and Council suggest that the Observatory of the British Association at Kew might, with much propriety and public advantage, be adopted as the central meteorological station. It already possesses the principal self-recording instruments, and the greater part of them have been in constant use there for many months. There will be no difficulty in obtaining, through the intervention of the Committee of Management, similar instruments for the affiliated meteorological stations, and in arranging for their verification and comparison with the Kew standards, as well as in giving to those in whose hands they may be placed such instructions as may ensure uniformity of operation. The records from the other stations may be received at Kew by post weekly, or more frequently if required, and may be at once arranged for such form of publication as may be most approved. It seems expedient that, if practicable, the stations which should be selected to act in concert and co-operation with Kew should be in localities where some permanent establishment of a scientific character exists, and where a certain amount of supervision may be secured. In this view the President and Council would suggest, as eligible, the following chain of stations, commencing from the south, viz. :—

		°	'
Falmouth—Polytechnic Institution	Lat.	50	9
Kew—Observatory of the British Association	,,	51	28
Stonyhurst—The College, which has already a magnetical and meteorological observatory	,,	53	0
Armagh Observatory	,,	54	21
Glasgow—University and Observatory	,,	55	51
Aberdeen—University	,,	57	9

"To these six stations the President and Council would have been very glad to add two others, one in the south-west and one in the north-west of Ireland. For the former of these, possibly Valentia may present a fitting locality, when an establishment shall have been formed there as the connecting link, by means of the Atlantic telegraph between Europe and America.

"Having answered thus generally, it may perhaps be desirable to add specific replies on the several points enumerated in Questions 1 to 9. Preserving the order in which the inquiries are made, the replies are as follow:—

"*Question* 1. The President and Council are of opinion that the objects specified in the Royal Society's letter of February 22, 1855, are as important for the interests of science and navigation as they were then considered.

"*Question* 2. Much has without doubt been accomplished in the collection of facts bearing on marine meteorology, but as no systematic publication of the results has yet been made, the President and Council are unable to reply more specifically.

"*Question* 3. The President and Council recommend that the sea observations should be placed in the hands of the Hydrographer, with a view to the introduction of the results into the Admiralty Charts.

They, however, at present have not sufficient information on the subject of the land observations which may exist in the office of the Board of Trade to justify them in offering any recommendation thereon.

" *Question* 4. The President and Council consider it very desirable that further observations should be made, especially with reference to oceanic currents and great barometric depressions, and generally on all subjects comprehended under the denomination of 'Ocean Statistics.'

" *Questions* 5 & 6. It appears from the late Admiral Fitz-Roy's reports, as well as from the explanations of Mr. Babington, that the storm-warnings have been based on inferences drawn from observations extending over a considerable area; and the President and Council recommend that they should be continued under the superintendence of that gentleman. Respecting the daily forecasts of weather, however, they decline expressing any opinion.

" *Question* 7. The President and Council are of opinion that it would be desirable that an annual report in a modified form should be made to the Board of Trade of the results from the storm-warnings in the preceding year, and should be communicated to Parliament, and thereby become known to the public.

" *Question* 8. A proper reply to this question would require information and involve considerations which would occasion an inconvenient delay in the transmission of this letter.

" *Question* 9. The suggestions of the President and Council in regard to the mode in which it appears to them that the important subject of 'Meteorology Proper,' or the 'Land Meteorology of the British Islands,' might be dealt with economically, and at the same time effectively, have been fully stated in the body of this letter.

" I have the honour, &c."

Resolved,—That the draft of letter now read be approved, and that the President be requested to transmit the same with his signature, to the Board of Trade as the reply of the President and Council.

Mr. Farrer to General Sabine.

" Office of Committee of Privy Council for Trade,
" Sir, Whitehall, October 24th, 1865.

" I am directed by the Lords of the Committee of Privy Council for Trade to acknowledge the receipt of your letter of the 15th June last on the subject of the Meteorological Department of the Board of Trade, and to thank yourself and the Council of the Royal Society for the valuable information, advice, and suggestions which it contains.

" The Council of the Royal Society discuss the system of weather telegraphy, and recommend that it shall be continued; they approve of the proposal to hand over to the Hydrographer to the Admiralty such part of the observations collected in the Meteorological Department of the Board of Trade as he can make use of in constructing charts for the use of seafaring men. And they discuss and recommend the adoption of a new system of making and recording meteorological observations on land.

" As regards, however, one branch of the subject, viz., meteorological observations made at sea, which formed the original object of the Meteorological Department, and the chief subject of the letter from the Royal Society of the 22nd February 1855, the Board of Trade are not satisfied that they fully understand the present views of the Royal Society.

" Your letter says in answer to Question 1, contained in my letter of the 26th May last, asking 'Are the objects 'specified in the Royal Society's letter of the 22nd February '1855 still as important for the interests of science and 'navigation as they were then considered?' that 'the President and Council are of opinion that the objects specified 'in the Royal Society's letter of 22nd February 1855 are 'as important for the interests of science as they were then 'considered.'

" And it further says in answer to Question 2, asking 'To what extent have any of these objects been answered 'by what has already been done by the Meteorological Department?' that 'much has without doubt been accomplished in the collection of facts bearing on marine meteorology; but as no systematic publication of the results has 'yet been made, the President and Council are unable to 'reply more specifically.' It is probably for the reasons contained in this answer, that whilst the other subjects above mentioned are fully discussed in your letter, the subject of these meteorological observations at sea is scarcely referred to.

" It is, however, essential that the Board of Trade should be rightly informed upon this point before they can determine what steps should be taken with regard to the Meteorological Department. What is the value of the observations at sea already collected? what steps should be taken to make them useful? and whether any, and, if any, what further observations of the same kind should be collected, are questions which must be answered before any final arrangement can be made with respect to the other points mentioned in your letter. With the view of clearing up these points the Board of Trade are disposed to suggest the appointment of a small committee, consisting, say, of three or four persons, to examine the whole of the data already collected by the Meteorological Department; to inquire whether any and what steps should be taken for digesting and publishing them; and also to report whether it is desirable that observations of a similar kind shall still continue to be collected. Such a committee would also in all probability be able to make valuable recommendations as to the mode in which the business of the department (if continued) shall be conducted, and as to the form in which the daily weather reports (by whomsoever they may be made) should be published.

" If the Royal Society concur in this suggestion, the Board of Trade would ask them to appoint, as a member of the committee, some gentleman whose acquirements would enable him to give valuable advice on the scientific part of the subject, and they would also ask the Admiralty to appoint another member. The Board of Trade will feel much obliged if you will favour them with the opinion of the President and Council on this suggestion.

" With reference to the subject of meteorological observations on land, the Board of Trade do not clearly understand whether the Royal Society think that they should be substituted for, or be in addition to the meteorological observations at sea, which were originally suggested by the Royal Society. They are disposed to agree with the Royal Society in thinking that any observations of a scientific nature would be better conducted under the authority and supervision of a scientific body such as the Royal Society, or the British Association, than of a Government Department. But they do not see how they could advise the Government to sanction any plan which would involve the establishment of two separate offices for meteorological purposes, one under the Board of Trade at Whitehall, and the other at Kew. It seems to them obvious that any assistance to be given by Parliament for meteorological purposes will be more advantageously employed if concentrated at one place, and in one set of hands, than it can be if distributed among different establishments.

" I have, &c.
" T. H. Farrer.

" The President of the Royal Society."

Letter No. 2, from the President to Mr. Farrer.

Sir, Burlington House, Nov. 2, 1865.

" I have laid before the Council of the Royal Society your letter of the 24th of October, in reference to the Meteorological Department, and am authorized to make the following reply:—

" The President and Council fully concur with the Board of Trade regarding the importance of inquiries being made into the value of the observations obtained at sea under the direction and guidance of the Meteorological Department of the Board of Trade, and into the steps which should be taken to utilize the results, as well as the importance of the further question, whether any, and, if any, what future observations of the same or of a similar kind bearing on ocean statistics should be collected. They will be quite ready to assist in this inquiry in the manner proposed, viz., by nominating one of their fellows conversant with such subjects as a member of the proposed committee.

" In reference to the last paragraph of your letter of the 24th October, they are of opinion that systematic meteorological observations at a few selected land stations in the British Islands are desirable, in addition to the meteorological observations at sea, in order to complete a suitable contribution from this country to the meteorological investigations now in progress in the principal States of Europe and America, under the authority of their respective Governments.

" If, in the communication from the Royal Society to the Board of Trade of February 22, 1855, which preceded the establishment of Admiral FitzRoy's office, the advantages to be derived from a continued and well-directed system of maritime observations were more particularly pressed, it was because at that time neither the instruments nor the modes of observation suitable for a well organized and efficient system of continuous *land* investigation were prepared. This was well stated by Lieut. Maury in a letter addressed to the United States Government, dated November 6, 1852, subsequently transmitted by that Government to the Earl of Clarendon, and printed in the papers which were presented to the House of Lords in February 1855. This difficulty no longer exists, having been entirely obviated by the self-recording system of observation for which the necessary instruments have been devised and brought into use at the Kew Observatory.

"The President and Council are not aware of any inconvenience likely to arise from entrusting the scientific supervision of such a system as they have recommended to a body such as the Kew Committee, acting under the authorization and control in regard to expenditure, of a public department. Precedents for such a course are not wanting.

"I have the honour to be, &c."

Resolved,—That the drafts of the letters and memorandum now read be approved.

Resolved,—That Mr. Francis Galton, F.R.S., be nominated by the President to be a member of the Committee to be appointed at the Board of Trade to examine the data from meteorological observations at sea, collected by the Meteorological Department.

The Board of Trade then appointed a Committee, consisting of

T. H. Farrer, Esq., Secretary of the Board of Trade,
Francis Galton, Esq., F.R.S., nominated by the President and Council of the Royal Society,
Staff-Commander Evans, R.N., F.R.S., Chief Naval Assistant to the Hydrographer, nominated by the Admiralty,

to consider and report on the subject generally.

The Report of this Committee was printed and presented to Parliament in the Session of 1866. It recommended, I., the resumption and extension of the researches on ocean statistics, with occasional and well-considered publication of results; II., the study of the weather phenomena in the British Islands by self-recording instruments at six selected stations, acting in correspondence with the Kew Observatory, and aided by dependible observations from other British stations.

On the 30th of August 1866, the Board of Trade informed the President of the Royal Society that the Report of the Committee (just referred to) had been approved by the Admiralty and by the Board of Trade, and that the Board was prepared to adopt and support the course recommended; but that, before doing so, the Board of Trade desired to learn the views of the President and Council on the measures proposed by the Committee; and, specially, whether those measures were, in the opinion of the Royal Society, well calculated to advance meteorological science in the most efficient way; and whether the machinery and establishment suggested by the Committee were such as were likely to answer their purposes; and finally, the Board desired to learn the views of the Royal Society with respect to the body under whose management and responsibility the establishments in question should be placed. The reply of the President and Council was returned on October 25th, 1866, conveying their approval, generally, of the recommendations of the Committee, and recommending that the department under whose care the observations, reductions, and tabulations are to be made should be under the direction and control of a superintending scientific committee, who should have (subject to the approval of the Board of Trade) the nomination of all appointments, as well as the power of dismissal, of the several officials receiving salaries or remuneration; that the services of the members of this Committee should be gratuitous, but that they would require the assistance of a competent paid secretary; and, finally, that if the nomination of the superintending committee should be entrusted to the President and Council of the Royal Society, they would be prepared to recommend gentlemen competent to undertake the duties.

In reply, the Board requested the Royal Society to name a committee of their own members to give their gratuitous services in the organization of the observatories recommended, and in the general superintendence of the "Meteorological Department."

The public services thus requested have been actively undertaken, and on the 1st of December 1866 a committee was formed of such of the Fellows of the Royal Society who were willing to devote themselves to the onerous and responsible duties of such an undertaking.

Estimates were required, and were furnished by them, of the probable cost of the organization and of the annual expense of the observatories; and in January 1868, being not more than six months after the passing of the estimates by Parliament, observatories supplied with self-recording instruments, prepared and verified at Kew, were working under competent superintendence and with a trained staff at each observatory, and had commenced their observations at Falmouth, Kew, Stonyhurst, Armagh, and Glasgow, with reason to expect that in six weeks or two months Valentia and Aberdeen would be added to the list.

I have thus stated, in perhaps rather more detail than might otherwise have appeared necessary, the steps which preceded the "foundation of the Department for Meteorological Observations," because an unusual degree of responsibility, as advisers of the measures adopted by Her Majesty's Government, has rested in this case upon the Royal Society; and for the same reason I shall be glad to add a brief statement of the working of the department from the date of its establishment.

Its operations may be classified under three heads, viz., A. Ocean Meteorology; B. Land Meteorology of the British Islands; and C. Weather Telegraphy.

A. The various investigations which were in progress at the time the Committee took charge of the office have been completed, and the results partly handed over to the Admiralty for embodiment in their Pilot Charts, and partly published independently.*

As a commencement of work on a new and more thorough system, it has been resolved to investigate the meteorological conditions of the district lying between 20° N. and 10° S. in the Atlantic Ocean, a region traversed by every ship bound south of the Equator. To this end the entire store of documents in the office has been most carefully examined, and the logs which have been found to be thoroughly trustworthy have been set aside for discussion. This preliminary examination is now all but finished, and it is hoped that the materials will all have been extracted so that the discussion can be commenced before the close of the present year.

Some idea of the probable value of the results to be expected from this work may be gained from the fact that the ships' logs in the office form the only existing collection of any magnitude, of observations made with standard instruments of an uniform pattern, and of which all errors and corrections are absolutely known.

The loan of instruments to observers is steadily carried on, and in addition the office supplies Her Majesty's Navy with all meteorological instruments used.

B. As regards the Land Meteorology of the British Islands, seven observatories have been established fitted with self-recording instruments; the stations are Aberdeen, Armagh, Glasgow, Valentia, Stonyhurst, Falmouth, and Kew.

Three of these observatories were at work on Jan. 1, 1868, and the remaining four within seven months from that date.

A year was occupied in overcoming the preliminary difficulties of organization, so that the discussion and publication of results did not commence till the year 1869.

Part I. of the Quarterly Weather Reports for that year appeared in July 1870, and Part IV. (completing the volume) is now in the press. This work contains complete reproductions of the continuous automatic records of the instruments produced by means of the pantograph, which admit of as accurate measurements for the determination of readings at any epoch as the original records do. The text of the report contains, with other information, tables of mean numerical results.

C. The system of Weather Telegraphy has been maintained and rendered more efficient. The office is in receipt of daily reports from numerous stations on our own coasts and in adjacent countries, and it transmits in return intelligence of existing weather to this country, and to France, Holland, Hamburg, and Norway. At the same time the systematic investigation of weather has not been lost sight of.

The further value which such an office as that which has been thus established by the Board of Trade may have in a country which has such extensive dependencies, as is the case with Great Britain, may be exemplified by the following communication recently received from the India Office, and the reply which has been made:—

---

* Charts of the surface temperature of the South Atlantic Ocean.

India Office, S.W.,
March 17th, 1871.

SIR,

1. I AM desired by the Secretary of State for India, with reference to the meteorological reports from India that have been forwarded to your address, to request that the Meteorological Committee will take the subjects of those reports into their consideration, and furnish His Grace the Duke of Argyll with any advice or observations that their experience may suggest.

2. The organization of Meteorological Departments was commenced in India in 1867. There are now official reporters to the Governments of Bengal, the North-west Provinces, and the Punjaub. In each of these Governments there is a series of stations where observations are regularly taken, the results of which are periodically forwarded to the reporter, who submits an annual report. The nature and scope of the observations are shown in the reports. In Madras 18 stations are to be established, under the supervision of Mr. Pogson, the astronomer. At Bombay there is a well-organized meteorological observatory, under Mr. Chambers, whose work is regularly forwarded to the Astronomer Royal; but no series of stations has yet been established throughout the Bombay districts, as is the case in the other Indian Governments.

Mr. Blanford, the Bengal reporter, has paid much attention to the laws of storms and to the observation of cyclones, and his objects embrace that department of meteorological science. The careful observation of all phenomena connected with the monsoons is another branch of Indian meteorology which is of great practical importance; and the results of the observations, if taken on a correct system, should be useful to the agriculturist and to the sanitary officer, as well as to other departments of science.

3. The Duke of Argyll believes that the Committee are in a position to give valuable assistance to the observers in India, and in furtherance of the objects of the Indian Government in organizing meteorological stations. It is desirable that the elements necessary for arriving at the required results should be well known, as well as that useless observations should not be accumulated. It is also very important that a system should be introduced uniform with those already adopted by the best observers in other parts of the world, in order to facilitate comparison, and thus make the Indian work useful to science generally. Other points will doubtless suggest themselves to the Committee on perusing the reports, both as regards methods of observing, the organization of the department, and the utilization of results.

The Duke of Argyll will be obliged for any observations on the whole subject with which the Committee may favour him.

I am, &c.
(Signed) J. COSMO MELVILL.

R. H. Scott, Esq.,
Meteorological Office.

Reply to the India Office.

April 9th, 1871.

THE sources of information which the Committee have found most useful in enabling them to gain a preliminary insight into the meteorological requirements of India have been Herr v. Schlagintweit's Report, vol. iv., with the plates accompanying it, and Mr. Glaisher's Report on the Meteorology of India, in the addenda to evidence taken before the Commissioners appointed to inquire into the sanitary state of the army in India, published in 1863.

From these it appears that while there is a very considerable number of meteorological stations, many of them of great importance and value, distributed over the country, there is, or was at the date of these reports, a great deficiency of organization. The Committee are glad to observe that the necessity for a better system is seriously felt in India, and that the local governments have already taken steps to institute systematic operations, as evinced by the several reports which you have had the kindness to forward from time to time, most especially those from Mr. Chambers, as regards not only his own observatory but the entire question propounded in your letter; and those from Bengal, the N.W. Provinces, and the Punjaub. Of these latter, the only document which refers at any length to details of organization is that first named, for Bengal, in which Mr. Blanford has classified his stations into three groups. In this particular he has in some degree followed the model of the Austrian system, as given by Dr. Jelinek in his "Anleitung zur Anstellung Meteorologischer Beobachtungen," Vienna, 1869.

The only other European organizations comprehending a large area of territory are those in connexion with the K. Statistiche Bureau in Berlin, and that at present being set in operation in Russia, by the advice of a committee of the Academy of St. Petersburg. This latter scheme is on a very large scale, as is requisite for the immense extent of the empire; it contemplates the establishment of 18 independent observatories, each with its own series of subordinate stations.

It would appear to the Committee that some plan should be set in operation in India, analogous to that just referred to, as in process of organization in Russia; and such a proposal would be the more easily carried out owing to the existence of the five distinct establishments referred to in your letter, two of which are observatories of a very high class of scientific merit. In the opinion of the Committee five local central stations would probably be sufficient for India, the entire extent of the country being apportioned between them, for at present it appears that the subordinate stations are restricted to certain provinces, and that large tracts of country are wholly unrepresented.

In order to secure an uniform system of collecting meteorological data and of discussing the results, it appears to the Meteorological Committee to be desirable that a principal meteorological office should be established, with a scientific director at its head, to whom the superintendents of the five local meteorological central stations would be subordinate, and would transmit the data of the observations taken at the several stations under their supervision. The Committee are informed that the present superintendents, in all cases, have other duties to perform, which are liable to interfere with their freedom of action, and prevent their travelling about to inspect their stations and see that the observations are being carried on properly. The Committee would therefore recommend that to each superintendent should be given the services of an assistant for the express purpose of travelling about and inspecting the stations,—a duty which should in their opinion be performed at least once a year, if not more frequently.

The services of this officer might also be available for imparting a better organization to the numerous meteorological observatories which they are informed have been established for several years past at many stations other than those appertaining to the present meteorological districts, *e.g.*, at all places where there are military or civil hospitals.

The benefits to be expected from this practice, both as regards the information to be derived from it, the methodical organization of the operations, and the instruction and encouragement which it affords to outlying observers, cannot be put forward too strongly.

The Committee would suggest that many advantages might accrue from the establishment of the principal Meteorological Office in London.

In such case the Government might secure for the director the benefit of the advice and guidance of an unpaid committee to whom he would be entirely responsible, as in the case of the Meteorological Office.

In the opinion of this Committee it would be most important that a complete set of instruments for the continuous automatic registration of meteorological phenomena should be supplied, if possible, to each of these five establishments referred to; or at least in every case in which the local district superintendent was able to hold out a prospect of being able to manage them properly; as, for instance, at Colaba Observatory, at Calcutta, and possibly at the college at Roorkee for the North-west Provinces. The records obtained from these self-recording instruments would serve as a standard of comparison for the results of the several eye observations taken at the stations to be affiliated to them in the surrounding districts.

The system of continuous registration adopted by the Committee at their own observatories is *photographic* as regards the record of atmospheric pressure and temperature, and *mechanical* with reference to wind and rain, and it may be said to have proved itself thoroughly satisfactory.

A set of these instruments is at present at the Colaba Observatory, and, for the information of the Indian Government, it may be worth stating the cost, as regards preliminary outlay for instruments, and annual expenditure for light and chemicals.

The facts are taken from the observatory at Valentia (Ireland), which is lit not with gas but with paraffin.

	£	s.	d.
Barograph and thermograph -	140	12	0
Lenses - -	44	8	0
Anemograph - -	75	15	0
Rain gauge	31	10	0
Tabulating instruments	22	10	0
Lamps, &c. -	22	0	0
Other fittings	48	13	0
Testing instruments and instruction to observers -	38	0	0
	£423	8	0

The annual expenditure for materials used averages about 40*l*.

The mode of discussion and publication of the results yielded by these observatories will of course form a most important subject of deliberation.

As regards the operations at the subsidiary stations, the Committee would impress on the Indian Government their very strong opinion that it would be most unadvisable to require a more extensive range of observations than can reasonably be expected from a single individual. There will then be every reason to hope and expect that numerous observers will themselves volunteer to register additional phenomena.

It will be very important to direct these desultory efforts so as to enable results of value to be elicited.

It seems hardly necessary to do more than draw the attention of the Indian Government to the importance of absolute uniformity as regards the instruments to be used and the methods of observing. If this cannot at once be attained it is at least indispensable to have all the barometers and thermometers carefully tested by comparison with standards, as without these precautions all labour spent on observing will be almost totally thrown away.

As regards the special lines of investigation which it would be most desirable to pursue, the Committee would only couch their suggestions in the most general terms. The conditions of climate which are experienced over the whole of India differ so widely from each other, according to the geographical situation of the respective stations, their distance from the sea coast, and their elevation above the sea level, that the questions which would have most local importance for an observatory like Madras, with reference to the agriculture and the sanitary conditions of the surrounding country, may prove to be comparatively unimportant for inland districts like the Punjaub and the N.W. Provinces.

At all the stations the phenomena connected with the grand characteristics of the meteorology of Southern Asia, the monsoons and their periodical changes, will of course demand attention.

The accurate measurement of the rainfall, which is intimately connected with the monsoons, and is largely modified by forest denudation and the progress of cultivation generally, is another point well worthy of the careful notice which it has already attracted, as evinced by the numerous gauges erected over the country. This question is of far higher importance in India than in these islands, owing to the all but total dependence of immense tracts of country on artificial means of irrigation for the production of their staple crops.

The examination into the course of cyclones, and possibly into the causes which give rise to them, will not fail to maintain the interest which has already been excited on the subject, especially in Bengal.

These and all other useful objects of inquiry would be carefully considered by the proposed director and committee, whose especial duty it would be to aim at results which should have a maximum value from the means at their disposal.

(Signed) R. H. SCOTT.

Dredging Expeditions.

The last subject on which the Royal Commission desire information is "the Dredging Expeditions," undertaken by the Admiralty, at the recommendation of the President and Council of the Royal Society in 1868 and 1869, to the north and west of the British Islands, and in 1870 to the Mediterranean.

The interest which the results of the *deep-sea* dredging by the *Swedes* in the vicinity of the Loffoden Islands had excited among British naturalists and geologists was brought strongly under the notice of the Royal Society by Professor Wyville Thomson and Dr. Carpenter, accompanied by an earnest recommendation that steps should be taken to obtain, through the aid of our own Government, a more thorough and systematic investigation of the zoology of the *deep sea*, especially in the *Northern Atlantic region*. In bringing this request under the consideration of the Admiralty, the Royal Society was greatly aided by the good offices of Admiral Richards, the Hydrographer, a member of the Council of the Royal Society.

The steam vessel, the "Lightning," was in consequence suitably equipped, and was employed on this service for three months, in the summer of 1868. In the following summer the work was resumed in the ship "Porcupine," and carried down to lat. 48°, and in 1870 was extended, in the same vessel, to the Mediterranean. Each expedition was accompanied by a suitable scientific staff, personally superintended by one or other of the two Fellows of the Royal Society whose names are mentioned in the preceding paragraph, or by Mr. Gwyn Jeffreys, F.R.S. The results obtained have already abounded in interest, and promise to do so increasingly. They are recorded in the Transactions and Proceedings of the Royal Society.

EDWARD SABINE,
President R.S

APPENDIX XII.

PAPER handed in by JOHN ANDERSON, C.E., LL.D., Superintendent of Machinery to the War Department, and Examiner in Applied Mechanics, Science and Art Department, South Kensington.

I have been nearly 30 years in the War Department. For 13 years I was lecturer on Applied Mechanics in the Royal Military Academy, Woolwich.

I was lecturer on the same subject for six years at the Royal Engineers' Establishment at Chatham; and four years lecturer on the same at the Naval School, South Kensington.

I have had great experience in the carrying out of mechanical engineering work generally.

I have organized a great number of important manufactories for small arms and other war stores.

For four years I was at the head of the Royal Gun Factory, Woolwich, and had to organize it for the manufacture of rifled guns.

I have been responsible for the careful expenditure of nearly three millions of the public money.

I have had the selection of several hundred men of a superior class, to fill important situations in all parts of the world, and I am well acquainted with the general qualifications of working men.

At all times and even now I have experienced difficulty in finding men with a moderate knowledge of the principles and an acquaintance with the properties and general characteristics of the chief materials with which we have to deal. This is the case even with highly skilled workmen, of course there are many exceptions, but a want of real knowledge is the general feature.

I consider it most desirable that a very much larger proportion of our workmen should be so educated even as a mere matter of expediency in a national point of view. Such knowledge immediately begins to tell on the character and ability of superior men; and, as a rule, tends to withdraw their attention from such subjects as trades unions, and leads them to take an interest in scientific questions, so far as they bear on their own speciality, and to increase their self-respect.

It is also pleasant to observe the increasing usefulness of such men, and the economical saving habits that are established, and which alone is a great reward, besides the prospect of future advancement which such knowledge opens up.

I am of opinion that the Government should foster such branches of science as bear directly or even indirectly upon practical operations, for there is not a practical operation of any sort which does not depend for its result on the action of a law of nature; these natural laws are observable in everything to the eyes of the philosophical workman, and afford immense pleasure even to those of more experience.

These remarks apply more especially to the foundry, smithery, and the other workshops of the engineer, yet many men spend their lives in them without observing the wonders of nature.

As a mark of my opinion in this respect, and the importance that I attach to such knowledge, I have offered an annual prize of 5*l*. to the best student in Applied Science at the Mechanics' Institution of my native place, Aberdeen.

Since the time when the results of the Science and Art Classes have been in operation, I have found a much superior class of young men to fill the situations in my own drawing office, and the comparison between them and the generality of those young men which I formerly had is great, not only in their increased stock of real knowledge, but in their general intelligence and their aptitude to work out any new question which comes up. In an office where such a variety of subjects are passing through daily, fresh questions, requiring investigation, are continually arising; after a preliminary discussion of the subject, some one is told off to thoroughly investigate the matter, and the assistance which I receive in this way I cannot express.

If there are a number of experiments to be made in connexion with such investigations, they are set about in a purpose-like manner, which results in giving precise facts that may be depended upon. At the present time one of the said draughtsmen is engaged in carrying out experiments on ropes made of different kinds of hemp, and under different conditions as regards the crane hook, pulley, arrangement of sling, and such like points.

I have in my time had many hundred experiments made by less educated and less scientific men, who yet performed them with extreme accuracy, but the superior intelligence induces closer observation and a greater facility in drawing attention to the minutiæ of the lesson which the experiment teaches.

Both of the young men here referred to have taken prizes at the Science Classes, and one of them was the first in honours a few years ago, and is now a teacher of Applied Science at the evening classes held in the Mechanics' Institution, Royal Arsenal, Woolwich, and it is interesting to see the zeal which is manifested.

The numerous attractions at Woolwich render it uphill work to raise a class and still more in keeping it together, especially so with the native youth, who, as a rule, are not so eager nor so ambitious, in a praiseworthy sense, as the sons of families from the north. At the same time the former are fully as good workmen in the performance of refined operations, and, generally speaking, are easier to get along with in the conduct of a large establishment.

As examiner in Applied Mechanics at South Kensington, I am pleased to observe in the students a growing acquaintance with the first principles of mechanics and the natural laws generally. At first there was a marked deficiency in that respect, which improves year by year.

Much depends on the teacher, for although the examiner does not know either the school or the name of the pupil, still he can at once detect the difference in the teaching from the reading of the papers. Hence they are mostly in groups of good, moderate, or bad. After the examination marks were awarded, Major Donnelly sent me for perusal the tables containing all the necessary particulars. I find that the first place in honours is taken by a joiner in Dublin, aged 23. It was a remarkable paper, for, although not quite perfect in every question, 370 marks were awarded out of 400. Yet, irrespective of that, it was a rare production for a workman.

The following table shows the general result of examination in Applied Mechanics, held May 1872:—

Grade.	Total Number of Papers worked.	Result in Classes and Per-centage of Papers worked					
		1st Class.		2nd Class.		Failed.	
		Number	Percentage	Number.	Percentage	Number.	Percentage.
Honours	19	1	5·2	6	31·5	12	63·1
Advanced -	91	17	18·6	59	64·8	15	16·4
Elementary	350	99	28·2	169	48·2	82	23·4
Totals	460	117	25·4	234	50·8	109	23·6

As a rule, better teachers are required; still, when we consider the difficulty, there is every reason for being surprised at so many having been found ready to do what has been done. I do not consider that the mere passing as a second class advanced pupil is sufficient as a standard, and, as circumstances admit, that standard should be raised.

The use of the black board is a great impediment to teaching. It wastes the time of the teacher, and the imperfect and indistinct diagram fails to fix the idea conveyed upon the mind of the student. This defect will be remedied shortly. The Lords of the Committee of Council on Education have ordered that proper diagrams be prepared for this purpose, from which cheap copies will be printed for the use of schools, and sold at a cheap rate to all who may require them.

Practical men who have the necessary education make the best teachers. This kind of knowledge is to them more of a reality, and is a part of their nature, than is the case with those who have book-learning only.

It is more than probable that the majority of teachers will be of the latter class, because the practical men will be taken up more readily for better paying work. It is not unlikely that the teachers in elementary schools generally will find it to be their interest to have evening classes. This is the case already, to some extent, but such teachers are of a superior class, at least so far as I am acquainted.

In dealing with so many small classes, the payment of teachers is a great difficulty. From 40 to 44 evenings per session have to be given to the course; hence it is not encouraging to have a few pupils, and consequently poor remuneration. In the Royal Arsenal the students pay 7*s.* 6*d.* for the course; to this has to be added the amount which is given by the Department. In looking over the lists I find that some teachers will earn a good deal, while others will scarcely have anything. Some pass every student, while another has 6 fail out of 7. It appears to me that a little more encouragement is required, until the young men become alive to the advantage conferred.

It is interesting to look over the list of avocations from which the students come forward: ploughmen, stationer's clerk, architect's assistant, grocer, teacher, founder, smith, engineer, fitter, stonemason, flax dresser, joiner, civil engineer, and so forth.

The value of a paper does not always depend on the literary ability of the student. Some who can scarcely express themselves in intelligible language or correct spelling have yet a good grasp of the principles, and discuss the geometry of motion in native, good sense, not often found in books; while others, with better education, write more correctly, but may not have caught sight of the natural principles of the question under consideration. Still it takes both to make the student a valuable man for the country.

I have read over the *précis* of Colonel Strange's evidence; there is much in that paper for careful consideration. When the subject was first mooted to me, I was more hopeful of the advantages to be derived from such a Council of Science than I am now; I fear that it would not fulfil all that might be expected; I speak entirely with reference to subjects in which I have been mixed up. For several years I was a member of the Ordnance Select Committee, and I served upon committees on guns, shells, and many other similar questions. My impression is that the Council, as a Council, would not advance them; that the real work of advance will depend on some willing member who will work hard and give it a great deal of thought, and that the after discussion will not affect the result beyond the point reached by the worker.

There are many scientific questions that should be undertaken at the public expense for the good of the country. Colonel Strange, in a quotation from a letter of mine, mentions one in reference to iron and steel. I consider that such minutiæ and other collateral questions cannot be worked out by private individuals. In 1847, after the fall of a railway bridge, a Royal Commission was appointed to investigate the question, and which was carried out during the following year in a most masterly manner, and was the means of throwing more light on a very intricate subject, especially in regard to the natural law of elasticity, than anything which has been done before or since in regard to that branch; still even in regard to that I am of opinion that the machinery employed, namely, a Royal Commission, was too cumbrous for the operation; there were too many employed and the experiments were not carried far enough. Two men would have been sufficient, and they should have gone on much farther; two of their experiments on 50 feet bars would seem to upset all former notions, if that experiment had been repeated many times, and a longer time taken, we should have had our knowledge increased very much. I likewise object to the way in which the knowledge obtained was given to the world; a ponderous blue book should be digested, and the lessons taught put into a form that practical men can easily overtake.

For such investigations it would seem to me that a smaller special committee of the best men, meeting occasionally, and not giving their whole time, could either originate or by communication with other scientific bodies or men in various parts of the country, suggest such subjects as require the pecuniary assistance of the Government for their investigation, and that the province of the Committee or Council should be to find out and nominate the best known man or men, who should be told off at the public expense to devote a few years exclusively to the point, and who should work in the same way that Faraday pursued his investigations.

From my experience of a Government Department, I fear that the services of such a body could not be turned to proper account; that the minutiæ of knowledge that forms the key to the questions referred to is more likely to be found outside such a Council, and that the discussions, however learned, would not warrant the Secretary of State for War to be guided by their advice, without referring to his own committee, which again depends on some quiet worker for its information: my remarks, however, only apply to those questions with which I am intimately acquainted.

APPENDIX XIII. (See the Evidence of Mr. Buchan, Vol. II., pp. 245–250.)

COMMUNICATION from the SCOTTISH METEOROLOGICAL SOCIETY.

To J. Norman Lockyer, Esq., F.R.S.,
Secretary to the Science Enquiry Commission.

Edinburgh, 4, St. Andrew Square,
August 16th, 1870.

SIR,

AT the suggestion of Dr. Lyon Playfair, M.P., I now, as honorary secretary to the Scottish Meteorological Society, and by the authority of the council of the society, transmit to you a copy of the statement recently drawn up respecting the claims of the society for a pecuniary annual grant from the public funds, to enable the society to carry on its operations, and I have to request that you will have the goodness to bring the society's claims, at an early period, before the Commissioners for Scientific Objects, with a view to their recommending such a grant being made.

I am, &c.
A. KEITH JOHNSTON.

SCOTTISH METEOROLOGICAL SOCIETY

EXTRACT from MINUTES of MEETING of COUNCIL, held on 14th June 1870.

The Council resumed consideration of the application to Her Majesty's Government for an annual grant. Dr. Keith Johnston, the Honorary Secretary, reported that having been in London lately, he, along with Dr. Lyon Playfair, M.P., had interviews with General Sir Edward Sabine, the Chairman, and Mr. Robert H. Scott, the Director of the Royal Society Committee, and that he had called the attention of these gentlemen to the suggestion of the Board of Trade, that the society should apply to the Committee for a portion of their annual grant of 10,000*l*., as some remuneration for services which are of a public nature and of great importance. He added, that whilst these gentlemen admitted that the society was entitled to aid from the Government, they said that the Royal Society Committee had nothing to give, the 10,000*l*. grant annually voted by Parliament being found inadequate for the purposes to which it was applicable, but that the Committee would be happy to apply to the society for copies of returns from some of their stations on the occasion of storms occurring. [See Enclosure No. II.].

The remuneration offered for such returns, in the opinion of Mr. Scott, Mr. Buchan, and Dr. Keith Johnston, would not amount to more than 5*l*. annually, and would be merely payment for extra work which would have to be done by a clerk employed by the society for that purpose. It might be an advantage to the Royal Society Committee to obtain these returns, but the giving of them would afford no aid to the Scottish Meteorological Society.

The Council, having given consideration to these statements, agreed that the failure of their negotiations with the Royal Society Committee should be reported to the Board of Trade and to the Treasury, with the view of asking both bodies to concur in recommending a special annual grant to the society.

With this view the council appointed a committee, with Mr. Thomas Stevenson, C.E., convener, to draw up a statement of the society's claims, in order that copies thereof may be submitted to Her Majesty's Government, the Scientific Commission, and Members of Parliament.

D. MILNE-HOME,
Chairman.

STATEMENT of CLAIM of the SCOTTISH METEOROLOGICAL SOCIETY for GOVERNMENT SUPPORT

1. The society has been established for 15 years, and has many stations.

The society was founded in 1855, and has, therefore, existed for 15 years. It began its operations with 33 stations. The present number of its stations is 90, exclusive of two stations which have been established in Iceland, and one in Faroe. On the Continent there are also stations in direct communication with the society at Damascus, Beyrout, Aleik, and Jerusalem in Syria, Larnaka in Cyprus, Janina in Greece, Pau in France, and Millbrook in Jersey.

It appears from this that the society is already a tried institution, with a broad and vigorous organization, and it is to maintain this that aid from Government is now needed.

The 90 schedules from these stations are first examined by the secretary for the detection of clerical or observational errors, and such errors, when discovered or suspected, are corrected and adjusted by communication with the observer. Of the 90 schedules, 55 are then taken to the Astronomer-Royal to be reduced for the use of the Registrar-General for Scotland, who publishes the results in his quarterly, monthly, and weekly reports. The remaining 35 schedules are reduced and averaged by the society's secretary.

2. The society does necessary public work for a Government officer, for which it receives no payment.

The society's observations form the basis of official reports on the health of the people by the Registrar-General, and without these observations it would be impossible for him to make his reports complete. This statement will not be questioned by anyone conversant with investigations relating to the public health, from which the influence of weather cannot be excluded.

The meteorological information so supplied to a public officer, for public purposes, is collected at great expense by a private society, whose operations are necessarily of such a nature as to involve a large outlay of money. The society now appeals for some remuneration from Her Majesty's Government for this work.

3. The rest of the society's work has also direct bearings on the public interests—more especially on navigation and agriculture.

But, independently altogether of the work done for the Registrar-General with reference to the question of public health, involving the society in an outlay of about 250*l*. yearly, the society engages in other matters which have a direct bearing on agriculture and navigation, including the investigation of storms and weather.

The society publishes a quarterly journal which contains the results of the observations of the stations for each quarter, and original papers on subjects connected with meteorology.

4. The society's work widely appreciated.

The society's observations so published have been much used by scientific men in all parts of the world, among whom may be mentioned Professor Dove, Berlin; Dr. Petermann, Gotha; Dr. Wojeikoff, St. Petersburg; Professor Mohn, Christiania; Dr. Buys Ballot, Utrecht; Dr. Jelinek, Vienna; M. Leverrier, Paris, &c.

The reports on the prevailing weather, as published in the society's journal, are frequently referred to as evidence in lawsuits, disputes connected with perishable goods, questions of water supply to towns, &c.

5. The society supplies meteorological information to foreign Governments at their request.

The society's returns of daily observations are highly valued by scientific men in foreign countries on account of the important geographical position of the society's stations in the north of Scotland, and in Iceland and Faroe. Copies of daily observations have been applied for by, and are sent to, the Imperial Observatory at Paris, the Meteorological Institute of the Netherlands, the Meteorological Institute of Norway, the Meteorological Society of France, &c., all these institutions being either wholly, *or in part*, maintained by their respective governments. For this international work the society makes no charge. The Meteorological Committee of the Board of Trade have also recently applied for copies of observations on wind and weather from 12 of the society's stations, which the council have agreed to supply.

6. The society not only makes but discusses observations dealing with the laws of weather.

The original papers which have been published in the journal are of a practical character, and present some of the fruit of the society's labours. Discussions of a broader nature, dealing with the meteorology of Europe,—or that of North America, the Atlantic, Europe, and Western Asia, have from time to time appeared, together with papers, in which the results are applied to important national questions, such as public health, navigation, and agriculture. That these papers are held in estimation by meteorologists and scientific men in this and other countries will be seen by consulting Enclosure No. 1.

7. The society has encouraged meteorology by prizes.

The society has also been enabled, through the liberality of the noble president of the society, the Marquess of Tweeddale, to offer prizes for sets of observations on special subjects, the results of which have been, in part, published by the society. The observations elicited by these prizes have been of the greatest value in determining, among other points, the temperature required in Scotland for the proper ripening of cereals, the effect of drainage on the temperature of the soil, and some of the peculiar effects of the east wind. In these, and other objects connected with the society, the noble president has generously expended several hundreds of pounds.

8. The society has great stores of undiscussed information.

Though much has thus been accomplished by the society in furthering the progress of meteorology, much more yet remains to be done, not only in overtaking the discussion of the very valuable material which has accumulated in the society's office, bearing on questions never hitherto discussed, but also in re-testing conclusions which were necessarily based on observations extending over a limited period of time. The funds of the society, moreover, do not admit of such frequent inspection of its stations as is desirable.

9. The society has
Only one paid officer, who is overworked.

The society only possesses one paid officer for carrying on its operations, and the labour involved in conducting the work greatly overtaxes his powers. The funds at the disposal of the council, drawn wholly from voluntary sources, are too limited in amount, and too fluctuating, to admit even of the employment of a clerk to relieve him of the mechanical work which devolves on him. By great devotion to duty, and an unusual capacity for the work in which he has been employed, the secretary has materially, and at no little sacrifice of self, aided the council in maintaining the society in its present state of efficiency, and in its service he has acquired a wide reputation as a meteorologist.

10. The claims of the society have already been acknowledged by the Government, and its appeal for aid rests on these claims.

In these circumstances the council has, on several occasions during the past two years, memorialized H.M. Treasury and Board of Trade. The claims of the society have been cordially acknowledged on account of the important services it has rendered to the public, especially for the information supplied to the Registrar-General, and the council trust that their claim for a special grant may be favourably considered.

THOMAS STEVENSON,
Convener of Committee.

ENCLOSURE No. I.

ORIGINAL PAPERS by the SECRETARY and various MEMBERS of the SCOTTISH METEOROLOGICAL SOCIETY, from the data collected by it, which, among others, have been either reprinted or favourably reviewed in Foreign and British Journals.

Titles of Papers.	*Foreign and British Journals where reprinted or favourably reviewed.*
1. On the Fall of Rain in Scotland during 1856 and 1857. By James Stark, M.D., F.R.S.E., etc.	1. Edinburgh New Philosophical Journal.
2. Remarks on Ozone. By Arthur Mitchell, M.D., F.R.S.E.	2. Edinburgh New Philosophical Journal.
3. Observations on the Florida Gulf Stream. By A. Keith Johnston, LL.D., F.R.S.E., F.R.G.S., etc.—The Temperature of the Sea on the Coast of Scotland. By Alexander Buchan, F.R.S.E.—Additional Observations on Temperature of Sea round Scotland and in Faröe and Iceland. By A. Keith Johnston and Alexander Buchan.	3. Petermann's Geographische Mittheilungen.—Temperature de la Mer entre l'Island l'Écosse, et la Norvége. Par Prof. Mohn, Christiania.—Edinburgh New Philosophical Journal.
4. On the Barometric Depression and accompanying Storm of 19th October 1862. By Thomas H. Core, M.A., Privy Council Lecturer on Mathematics.	4. Edinburgh New Philosophical Journal.
5. On the Importance of the Study of Medical Climatology. By R. E. Scoresby-Jackson, M.D., F.R.S.E.	5. Medical Times and Gazette.
6. Examination of the Storms which occurred in Europe in October, November, and December 1863. By Alexander Buchan.	6. Transactions of the Royal Society, Edinburgh.—Zeitschrift der österreichischen Gesellschaft für Meteorologie.—Nuova Antologia di Scienze, Littere, ed Arti, Firenze.
7. The Isothermals of the British Isles for January, April, July, and October. By Alexander Buchan.	7. Journal of the Agricultural Society of England, etc.
8. On the Cold Weather of May. By Arthur Mitchell.	8. Zeitschrift der österreichischen Gesellschaft für Meteorologie, etc.
9. Interruptions in the Rise and Fall of Temperature in the course of the year. By Alexander Buchan.	9. Zeitschrift der österreichischen Gesellschaft für Meteorologie.
10. Popular Weather Prognostics of Scotland. By Arthur Mitchell.	10. Edinburgh New Philosophical Journal.—Transactions of Royal Highland Agricultural Society.—Proceedings of English Meteorological Society.
11. On the Temperature of Drained and Undrained Land. By D. Milne-Home, LL.D., V.-P.R.S.E., and Alexander Buchan.	11. Scottish Farmer and other Agriculture Journals.
12. A comparative view of the Winter climates of Edinburgh, Jersey, and Mentone.—Note on Weather of March 1867, and on some effects of East Winds.—Are Exceptions in the Distribution of Temperature associated with Exceptions in the Distribution of Disease and Death?—On the cause of some of the pernicious Effects of Polar Winds, with remarks on the method and scope of Medical Meteorology. By Arthur Mitchell.	12. Those Papers by Dr. Arthur Mitchell, Convener of Medico-Climatological Committee, have been largely reviewed in Medical Journals; among others, the Medico-Chirurgical Review, Medical Times and Gazette, Dublin Medical Journals, etc.
13. On the Climate of Jerusalem. By Thomas Chaplin, M.D., and Alexander Buchan.	13. Monatsberichte K. Akademie der Wissenschaften zu Berlin.
14. On ascertaining the Intensity of Storms by calculation of the Barometric Gradients. By Thomas Stevenson, F.R.S.E., Civil Engineer.	14. Zeitschrift der österreichischen Gesellschaft für Meteorologie.—Report of an Inquiry into the connection between Strong Winds and Barometrical Differences. By Robert H. Scott, Director Meteorological Committee.—Journal of Science, London.—Medico-Chirurgical Review.
15. Mean Temperature of every day in the year at Arbroath for 22 years. By Alexander Brown, LL.D., and Alexander Buchan.	15. Zeitschrift der österreichischen Gesellschaft für Meteorologie.
16. On Two Storms which passed over the United States in March 1859, and on Storms which occurred at the same time in N. America, Europe, and Western Asia. By Alex. Buchan.	16. Nouvelles Météorologiques de la Société Météorologique de France.—Journal of Science.
17. On the Meteorology of Iceland. By A. Thorlacius and Alexander Buchan.	17. Zeitschrift der österreichischen Gesellschaft für Meteorologie.
18. On the Weather of North-Western Europe during 1868. By Alexander Buchan.	18. Atlas Météorologique de l'Observatoire Impérial de Paris.

19. Note on the Barometric Measurement of Heights, chiefly in the interior of Continents. By Alexander Buchan.	19. Proceedings of the Royal Society of Edinburgh.—Petermann's Geographische Mittheilungen.—Zeitschrift der österreichischen Gesellschaft für Meteorologie.—Journal of the Royal Geographical Society.
20. Thunderstorms of Scotland. By Alexander Buchan.	20. Nouvelles Météorologiques de la Société Météorologique de France.—Zeitschrift der österreichischen Gesellschaft für Meteorologie.
21. On Rotatory Storms, as illustrated by the Phenomena of Waterspouts and Whirlwinds. By D. Milne-Home, of Wedderburn.	21. Journal of Science.
22. On Chemical Climatology. By Angus Smith, Ph.D., F.R.S.	22. Journal of Science.
23. On the Mean Pressure of the Atmosphere, and the prevailing Winds over the Globe. By Alexander Buchan.	23. Transactions of the Royal Society of Edinburgh.—American Journal of Science.—Petermann's Geographische Mittheilungen.—Nouvelles Météorologiques de la Société Météorologique de France.—Zeitschrift der österreichischen Gesellschaft für Meteorologie.—Journal of Science.—Symons's Meteorological Magazine, &c.
24. Suggestions for increasing the Supply of Spring Water at Malta, and improving the Climate of the Island. By D. Milne-Home, LL.D.	24. Reprinted *in extenso* in a State Paper by the Local Government of Malta; and in the Zeitschrift der österreichischen Gesellschaft für Meteorologie:—it being republished, as stated in both cases, on account of its important bearings on the improvement of the climates of Malta, and of the Sea Coast of Dalmatia and Islands adjoining.
25. On the Effects of Solar Radiation in Relation to the Crops. Address by the Marquess of Tweeddale.	25. "Nature."

ENCLOSURE No. II.

No. I.

To the Lords Commissioners of Her Majesty's Board of Trade.

The Memorial of the Scottish Meteorological Society.

Sheweth,—That the council are desirous of respectfully asking your Lordships to consider whether, looking to the important public objects of the society, and also to the manner in which the society is working out these objects, Government aid ought not to be granted to the society.

Your memorialists refer to the applications made during the past two years, as they fully explain the grounds on which the council think that the society deserve and ought to receive this aid.

They beg further to mention, that a deputation of the members of council, supported by a number of Scottish Members of Parliament, waited upon the Chancellor of the Exchequer in April 1869, when the Chancellor, whilst admitting the value of the society's proceedings, suggested whether a further appeal should not be made to the Scottish public to give the additional revenue asked from the Government. It is proper that the council should now state that, in compliance with that suggestion, they did make a special and earnest appeal to the public in Scotland, supporting it by an intimation that they had applied in vain to the Government. The council regret to say that this appeal was attended with a very inadequate amount of success, not more than an additional sum of annual subscriptions to the amount of about 15*l.* having been obtained, which the council hesitate not to say was caused to a great extent by a strong feeling in Scotland that the public had already done quite enough to aid the society by giving subscriptions to an amount varying between 350*l.* and 400*l.*, and that it was the duty of the Government to give a grant, looking to the character of the society, and the public appreciation of its objects and proceedings.

The council, therefore, now return to Her Majesty's Government, and renew their application for pecuniary aid; and they think it right distinctly to inform the Government, that unless such aid be given it will be necessary to curtail much of the important and useful work which they have hitherto carried on. The grounds on which they deem themselves entitled to aid are briefly these:—

In the first place, they are a scientific body, which it is universally admitted has greatly advanced the science of meteorology.

Secondly, they are a body which supplies one of our own Government departments, viz., that of the Registrar-General, with information, which this department makes use of and publishes, but does not pay for.

Thirdly, the society supplies several Foreign Governments with information, at the special request of these Governments, and without making any charge against them.

Your memorialists very respectfully submit that Government ought to give an annual grant, equal in amount to the annual subscriptions of members—a principle which has been generally adopted by Her Majesty's Government in other matters of a public nature.

Were such grant given, the society would be able not only to continue carrying on the work they now perform, but even to extend their field of usefulness. At present the revenue of the society falls short of the necessary expenditure; they cannot even afford to assist their secretary with a clerk, and have it not in their power to publish many of the investigations which he carries on.

(Signed) D. Milne-Home,
Chairman of Council.

Office of the Scottish Meteorological Society,
Edinburgh, 5th March 1870.

No. II.

Meteorology.

Board of Trade, Whitehall Gardens,
April 6th, 1870.

Sir,

I am directed by the Board of Trade to acknowledge the receipt of your letter of the 8th ultimo, enclosing, at the request of the Meteorological Society of Scotland, a memorial, praying the Board of Trade to move the Treasury to give them an annual grant.

In reply I am to state that this Board have carefully considered the memorial and the statement enclosed in your letter, and that they are unable to find any grounds on which they can entertain and submit to the Treasury any proposition for a separate grant of public money to the Scottish Meteorological Society.

The Board of Trade will, however, be pleased to hear at any time that an arrangement has been effected between the Meteorological Committee of the Royal Society and the Scottish Meteorological Society, whereby the Scottish society will co-operate in carrying forward the objects sought to be attained by the Meteorological Committee. If, and when such an arrangement is made, the Board of Trade are satisfied that the Meteorological Committee will pay to the Scottish society a proper sum in consideration of the services rendered.

I am, &c.
Thomas Gray.

Dr. Lyon Playfair, M.P.,
House of Commons, S.W.

No. III.

Excerpt from Minutes of a Meeting of the Council of the Scottish Meteorological Society, held on 26th April 1870.

The meeting had at the same time before them the answer by the Board of Trade to the memorial of the Council asking for a separate grant of public money, in which answer their Lordships state, that whilst unable to move the Treasury to give a special grant, their Lordships would be pleased to learn that an arrangement had been effected between the Meteorological Committee and the Scottish society, whereby the latter will co-operate in carrying forward the objects sought to be attained by the Committee. The council resolved to agree to this proposal, and, in accordance therewith, to intimate their desire to co-operate with the Committee, leaving to the Board of Trade to fix the amount of the sum to be paid in consideration of the services rendered.

In any such arrangement it will of course be understood that the independence of the society in the management of its affairs shall be in nowise affected.

The council further resolved that a copy of this minute shall be communicated to the Meteorological Committee, and also to the Board of Trade.

D. MILNE-HOME,
Chairman.

No. IV.

METEOROLOGY.

Board of Trade, Whitehall Gardens,
May 10th, 1870.

SIR,

I AM directed by the Board of Trade to acknowledge the receipt, on the 28th ultimo, of an abstract from the minutes of a meeting of the council of the Scottish Meteorological Society held on the 26th ultimo.

The Board of Trade desire me to state, that as it rests with the Meteorological Committee to take such action in the matter as they may be advised and may determine, and as a copy of the excerpt has apparently been forwarded to that Committee by your society, this Board will no doubt, in due course, hear from that Committee the result of any negotiations between them and the Scottish Meteorological Society.

I am, &c.
THOMAS GRAY.

The Secretary,
Scottish Meteorological Society.

No. V.

Edinburgh, May 13th, 1870.

DEAR SIR,

I REGRET that you did not clearly understand the meaning of the communication I sent to you from our council meeting of the 26th ultimo.

It may not have been very explicitly stated in my letter, as the papers were not at hand at the time.

But our meaning was simply to ask if your Committee are prepared to recommend to the Board of Trade that we should have the grant of such a sum of money as will enable us to engage a clerk, and other assistants, in order that we may co-operate with you in the manner indicated by the Board of Trade.

It will therefore be a favour if you will bring the matter before your Committee on Monday next and communicate to me the result of their deliberations by that day's post, in order to guide the society in their future proceedings.

Yours, &c.
A. K. JOHNSTON.

Robert H. Scott, Esq.
Director, Meteorological Office.

No. VI.

London, May 16th, 1870.

SIR,

IN reply to your note of the 13th instant, I am directed to acquaint you that the Meteorological Committee are not prepared to recommend to the Board of Trade that your society should receive a grant of money to enable them to engage a clerk and other assistance.

The co-operation the Meteorological Committee proposed is explained in my letter of January 19th and in the memorandum (No. 17) already forwarded, and of which I now enclose another copy.

You will observe by the first paragraph, second page, that the form is to be filled up only "whenever a storm or "very sudden change of weather is noticed, and also occa-"sionally when specially requested by letter."

The expense incurred from time to time in obtaining and forwarding this information the Meteorological Committee are prepared to defray.

I have, &c.
ROBERT H. SCOTT.

A. K. Johnston, Esq., LL.D.

COMMUNICATION from the BOARD of TRADE.

METEOROLOGY.

M. 2792.

Board of Trade, Whitehall Gardens,
April 6th, 1871.

SIR,

I AM directed by the Board of Trade to transmit to you for the information of the Scientific Commissioners, the accompanying application from the Scottish Meteorological Society for Government assistance. [*See* the Communication from the Society, forming the first part of this Appendix XIII.].

The application in question does not appear in any way to concern the Meteorological Committee or the Board of Trade.

I am, &c.
THOMAS GRAY.

J. N. Lockyer, Esq.,
Secretary to the
Royal Scientific Commission.

(Enclosure.)

M. 2792.

Yester, Haddington,
March 21st, 1871.

SIR,

BY desire of the Council of the Scottish Meteorological Society, I forward a statement of claim of that Society for Government support.

The grounds of our claim have been drawn up by Mr. Thomas Stevenson, C.E., Chairman of the Committee appointed for that purpose. [*See* pp. 64, 65.]

I trust that the grounds stated for our claim may meet with a favourable consideration from the Scientific Commission, and that the Commission may be pleased to recommend it to Her Majesty's Government.

I am, &c.
TWEEDDALE.
President of the Scottish Meteorological Society.

APPENDIX XIV. (See the Evidence of Mr. Milne-Home, Vol. II. pp. 250-261.)

MEMORIAL of the COUNCIL of the ROYAL SOCIETY of EDINBURGH.

To the Royal Commissioners appointed to make inquiry with regard to Scientific Instruction and the Advancement of Science, and the aid thereto derived from grants voted by Parliament.

The MEMORIAL of the COUNCIL of the ROYAL SOCIETY OF EDINBURGH.

Your Memorialists having been informed that the Commissioners are ready to receive from any quarter information and suggestions bearing on the important questions awaiting their consideration, beg respectfully to submit to them the following statement:—

The Royal Society of Edinburgh was established in the year 1782. Its founders desired by means of it to promote the interests of literature and science in Scotland. The published transactions of the society, now numbering 26 quarto volumes, show that its members have assiduously devoted themselves to both branches of knowledge. Science, however, has been its chief business. Every year memoirs are brought before its meetings, on mathematics, natural philosophy, geology, archæology, botany, zoology, meteorology, chemistry, anatomy, physiology, and other subjects. The most important of these are published in the Society's Transactions.

As science, in its varied departments, expanded and multiplied, it became impossible for one society to render all the aid necessary for each. Hence other societies from time to time sprang up in Scotland, to supplement what the Royal Society was not able to overtake.

The following are societies in Edinburgh devoted to particular branches of science: The Royal Scottish Society of Arts, the Royal Physical Society, the Geological Society of Edinburgh, the Society of Scottish Antiquaries, the Botanical Society, and the Scottish Meteorological Society. There are also in Glasgow, Aberdeen, St. Andrews, and

Perth, several societies devoted to geology, natural history, and literature, several of which publish transactions.

As the Royal Society of Edinburgh, which your memorialists represent, is of older standing than most of the other societies, besides being more comprehensive in its design, the memorialists think it not unbecoming their position to address the Commissioners with reference to the question how and to what extent science is aided by the State in Scotland.

Your memorialists presume, from the terms of the Commission, that there are two inquiries embraced by it.

By "*scientific instruction*," is probably meant, the teaching of science at institutions devoted to instruction, by means of professorships and public museums.

By "*advancement of science*," is probably meant, the discovery of new facts, new principles, and new processes, by means of original observations, experiments, or inquiries.

Your memorialists do not think it necessary to advert at any length to what is done in Scotland by the State, for aiding in *scientific instruction*. Their own society and the other societies to which reference has been made, were established not so much for *teaching* as for *advancing science*; and if they were to enlarge on the first of these objects, it might be thought that they were stepping beyond their proper province. They therefore confine themselves in this memorial to the question, what aid is now given by the State for the advancement of science in Scotland?

Before addressing themselves to this point they may perhaps be allowed to say that they are by no means insensible to the generosity of the State as indicated by the pecuniary grants recently made for the establishment of an Industrial Museum in Edinburgh, and for the endowment of three Professorships in the University of Edinburgh, aided by local contributions. But these grants have reference only to the first of the objects about which the Commissioners are to inquire, viz., scientific instruction. They have little or no bearing on the advancement of science, in so far as such advancement results from searching after new facts or new truths, or extending our knowledge to limits not previously reached.

It may perhaps be asked in what way the State can promote the advancement of science?

On the Continent there exist certain institutions, fitted with instruments, apparatus, chemicals, and other appliances, which are meant to be, and which are made available for men of science, to enable them at a moderate cost to pursue original researches. It has accordingly been frequently suggested that our Government ought to establish similar institutions, to be called Colleges of Research, in each of the three divisions of the United Kingdom.

These suggestions have not yet been acted on. Men of science in this country when they make discoveries, do so commonly at their own cost, or with what aid they can get from societies of which they are members. But discoveries can now seldom be made in any of the sciences by appliances of the simple and inexpensive kind formerly available. In the infancy of science, discoveries of important facts can be made by observations, as it were, on the surface; but no discoveries can be expected now, except by digging below the surface, and digging deep, of course, with great labour and cost. The consequence is that in the present day scientific investigations are carried on principally by those who have private fortunes of their own, and who are willing to spend them in that way, or by those who can obtain help from other sources.

If the Commissioners desire evidence at once of the necessity and the utility of pecuniary grants to men of science, they have only to look at the application of an annual grant of 1,000*l.* made to the Royal Society of London in the year 1849, and which is still continued.* The printed parliamentary returns of the application of this grant show, for example, that by means of it Dr. Carpenter was enabled to prosecute researches in marine natural history; Dr. Tyndall in magnetism and glaciers; Professor Sir William Thomson in electro-dynamics; Mr. Mallet in earthquake phenomena; Professor Owen in palæontology; Dr. Roscoe in photo-chemistry; Mr. Balfour Stewart in temperature; Dr. Hooker in botanical inquiries; Mr. Lockyer in solar spectroscopic observations; and Professor Phillips in lunar examinations, not to mention many more. Geological explorations also have been undertaken, meteorological observations have been made, and a party of astronomers were sent with instruments to Spain, to view a solar eclipse, all by means of that grant.

The results of the experiments, researches, and observations so promoted by the above-mentioned grant were most important; for your memorialists take leave to say, that it is quite as desirable to discover new truths, as to teach old truths. If Great Britain is to keep a proper position in the family of nations, or desires to add to her own material prosperity and wealth, her government will aid men of science in extending the boundaries of knowledge.

Allusion has been made to the assistance obtained from scientific societies. In fact the sole aim of these societies is to afford that aid, though they are seldom rich enough to do so by giving money. The only society in Scotland, so far as the memorialists know, which has been able to aid in this way is the society which they represent. Its present income from the entry money and annual contributions of its members, is about 1,100*l.* The greater part is expended in printing and publishing important memoirs, illustrated by expensive plates, and in circulating these among the principal universities and public libraries of the world. But occasionally the council of this society has had a surplus of funds after paying the cost of meetings and of publishing transactions, and then they have readily responded to applications for the purchase of costly instruments, or for the publication of valuable observations made by fellows, or for special geological investigations.

Another of the societies before mentioned devotes its funds (about 120*l.* yearly) to two objects,—*First*, the collection of meteorological observations from about 85 stations in Scotland, embracing also the Faroe Islands and Iceland; and *Secondly*, the discussion of these in order to discover the laws which determine atmospheric fluctuations. This society publishes these observations and discussions quarterly, and disseminates them among the observatories of Europe.

Several other Scottish societies are able to print and publish the memoirs read at their meetings, by which means any new facts discovered, or any new processes invented, or any important theories suggested by their members, are made known to the world.

And even where a society's funds may not be sufficient to do more than hire a room for meetings, the advancement of science is promoted by bringing men of science together that they may communicate information to one another, and co-operate in any special investigation.

Your memorialists, now that they have made the statements, have really stated all that can be said in explanation of what has been done, or is being done, in Scotland to aid men of science in original researches. The State at this moment literally contributes nothing, either directly or indirectly, towards that important object, in this northern division of the United Kingdom.

There are not wanting men of science in Scotland both ready and qualified to engage in such researches; but in carrying these on they are left to their own resources, except in so far as help is obtained from some affluent friend or patron, or from some society of which they are members.

The only society in Scotland in receipt of pecuniary aid from the Imperial Treasury is the Royal Society of Edinburgh. They receive 300*l.* yearly to pay the rent of the apartments in which they have their library and their meetings, but no grant is made to enable them to pay for original researches, experiments, or observations, or for the printing and publication of the transactions.

The Scottish Society of Antiquaries is permitted to hold its meetings, and to keep its library in a Government building, and no rent is charged. But, on the other hand, no grant is made to aid it in searching for and explaining ancient historical relics, in deciphering curious old manuscripts and stone sculpturings, or in printing its transactions.

The Scottish Meteorological Society is allowed the use of two small apartments on the attic floor of the General Post Office. For these it pays a rent of 30*l.* besides the cost of furnishing, lighting, heating, and cleaning the apartments. No grant is made to the society to aid in carrying on its observations, or in discussing or publishing them; and, moreover, Government takes from the society such meteorological information as the Scotch Registrar General requires for his quarterly returns, without paying for it.

Your memorialists submit that one obvious method by which the advancement of science in Scotland could be greatly promoted would be by the State assisting those societies with pecuniary grants, and making the grants bear some relation to the amount of income derived from the annual subscription of members.

The State makes large advances to various societies in England and in Ireland, to aid in their objects, not only societies for advancing science, but societies for encouraging the fine arts, teaching music, and exhibiting zoological collections. Why should the same State patronage not be given to Scottish societies, to aid original scientific researches?

---

* For an account of the origin and administration of this Parliamentary grant, see a Memorandum by Dr. Sharpey, Secretary of the Royal Society in London, in the Proceedings of the Royal Society of Edinburgh for the current year, page 302.

There is an annual grant by Parliament of 10,000*l.* a year for meteorological purposes, applicable to the whole United Kingdom, and a part of the grant is expended in Scotland, for instrumental observations, but the administration of it is vested exclusively in a Committee of the Royal Society of London. The Scottish Meteorological Society is greatly in need of assistance. Its claims have been admitted by the Treasury and the Board of Trade, yet no portion of that grant comes to the aid of the Scottish society.

Reference has been made to the annual grant of 1,000*l.* for aiding scientific investigations generally in the United Kingdom. The administration of it also is entirely in the Royal Society of London. Were any means ever taken to make it known in Scotland or Ireland that there existed such a grant, by which scientific researches in these countries might be aided? The memorialists after inquiry, have not been able to discover that such notice was given. The probability is that none was given, for during the 21 years in which this grant has existed, no men of science in Scotland have obtained a share of it except three, two being Fellows of the Royal Society of London.

Perhaps it was owing to the circumstance of the grant not being sufficiently known that the Royal Society of London have sometimes experienced a difficulty in expending it. In the year 1864 the society honorably paid back the whole year's grant to the Treasury, in consequence of no claims on it.

That the existence of this grant was till lately as little known in Ireland as in Scotland may be inferred from the following paragraph in the Report of the Royal Commissioners on Science and Art in Ireland in the year 1869:—"Representations have been made to us as to the want of "funds in the hands of the Irish Academy to enable them "to assist persons engaged in original researches. Such a "grant appears to be unnecessary, as the sum of 1,000*l.* "per annum at the disposal of the Royal Society of London "is applicable to the whole kingdom, and we believe is "scarcely ever wholly expended. If this were generally "known in Ireland, it would probably meet the wishes "expressed on this point."—P. xiv.

This grant of 1,000*l.*, therefore, has been of little or no benefit to science in either Ireland or Scotland, and in one respect has done harm, by affording to the State an excuse for not aiding scientific societies or men of science in these countries.

Your memorialists, however, do not ask or wish that the administration by the Royal Society of London of either the grant of 1,000*l.* for general science, or the grant of 10,000*l.* for meteorology, shall be interfered with. Any attempt to conjoin with them another society, and especially one situated so far off as Scotland, would be inexpedient; and to clip off a portion of the first-mentioned grant, in order to give it to Scotland, would also be inexpedient, as it is evident that the whole of that grant can be usefully expended in England. But it is plain, from the constitution of the grant, as explained in Dr. Sharpey's memorandum before referred to, that the intention of the Government in proposing, and of Parliament in sanctioning the grant, was, scientific research in Scotland was to be aided by a yearly allowance from the Imperial purse; and the only way of carrying out that intention is by now appropriating a special grant for Scotland, and by arranging that it shall be administered in Scotland.

In the foregoing remarks your memorialists have urged two reasons why there should be a pecuniary grant for aiding scientific researches in Scotland. *One* is, that it is for the well-being and honour of the country that such aid should be given. The *other* is, that the State intended such aid to be given, but that the arrangements for carrying out that intention have miscarried. Your memorialists would now urge a *third* reason, founded on the very small amount of the allowances for any local objects whatever, advanced from the Imperial Treasury for Scotland, compared with the amount advanced for England and Ireland.

Your memorialists, however, will abstain from remarking on the large and liberal amount of the Imperial advances to societies and institutions in London. The immense population of that city, and the fact that it is the capital of the United Kingdom, justify these advances.

But Scotland and Ireland stand on a more equal footing; for though Ireland has a larger population than Scotland, on the other hand—and this is more to the purpose—Ireland contributes far less than Scotland to the Imperial Treasury. A Parliamentary return, obtained in 1869 by a Scotch Member of Parliament,[*] shows that whilst about 18,000,000*l.*, sterling, are drawn annually from Scotland for inland revenue, customs, and post office, only 13,000,000*l.*, sterling, are, under these heads, drawn from Ireland. In Scotland every individual of the population contributes 5*l.* 12*s.* yearly to the Imperial Exchequer, in Ireland, only 2*l.* 8*d.*

Comparing, therefore, what is drawn by the Imperial Government from Scotland and the people of Scotland with what is drawn from Ireland and the people of Ireland, Scotland assuredly deserves to be treated, in respect of aid to its societies and institutions, quite as generously as Ireland. But how stands the fact?

Your memorialists append to this memorial a list of the societies and institutions in Ireland and Scotland respectively, which receive grants from the Imperial Treasury, and the amount of those grants. The information is taken from the Parliamentary estimates for the year ending 31st March 1871. From this list it will be seen that whilst in Ireland, the advances from the Imperial Treasury amount to 598,993*l.*, in Scotland they amount to 149,795*l.*, or about one fourth; and, moreover, that of the Scottish allowance, a very large proportion is for new works nearly completed, and therefore soon to be discontinued.

Your memorialists think it only right to apprize the Commissioners that a strong feeling, founded on these facts, prevails among all classes in Scotland, of the niggardly treatment of all her societies and institutions by those who hold the national purse. Assuming it to be right to give 598,993*l.* yearly to Ireland for objects of local interest, it is considered unfair and unjust to allow only 149,795*l.* yearly to Scotland for similar objects. There is now an opportunity of rectifying this wrong, by bestowing on societies in Scotland, established for the advancement of science and knowledge, that aid which will be serviceable to them, which it is for the public interest they should receive, and for which a precedent is afforded by the grants bestowed on the Royal Society of London.

As all the societies named in this memorial aim at the advancement of science in one or other of its many branches, it would be invidious and wrong to say that any of these societies are more entitled than others to be aided by the State. But it is proper that the Commissioners should be informed of certain peculiarities affecting two of these societies, which greatly strengthen their claims.

The Royal Society of Edinburgh does not devote itself to science alone, but to literature also; and not to one science only, but to many sciences. Moreover, the contributions of its members are such as enable it to circulate above 200 copies of its transactions and proceedings gratuitously among the universities, public libraries, and distinguished men of both Europe and America.

The Scottish Meteorological Society aims, as its primary object, at discovering the laws which regulate the movements and varying conditions of the atmosphere. But it also seeks to explain the bearings of these laws on important public interests; as in matters of climate, health, disease, crops, rainfall, storms, &c. It is from the society that the Registrar-General, a Government functionary, obtains the information indispensable for his quarterly returns. Other departments of the Government (Admiralty, and Board of Trade) have occasionally applied to the society for returns, and have obtained them. The society also supplies the Government observatories of many foreign countries with meteorological information. It may be added that one of our own colonies (Malta) lately adopted suggestions which came from the society, for improving the climate and the water supply of the island, its legislative council voting 800*l.* yearly for 10 years, to carry out these suggestions.

Your memorialists, in concluding these statements, would express a hope that the Commissioners will give to all the societies in Scotland an opportunity of stating what they are severally doing, in carrying out the objects for which they were established.

In the name and by authority of the Royal Society of Edinburgh,

R. CHRISTISON, President.

---

[*] Mr. M'Laren.—Return, ordered by the House of Commons to be printed 2nd March 1869, No. 52.

ENCLOSURE.

Advances to Societies and Institutions from the Imperial Treasury as stated in the Estimates for the year ending 31st March 1871.

I.—IN SCOTLAND.

1. Scottish Universities—yearly maintenance		£16,724
2. Botanic Garden (belonging to Government)—		
Maintenance	£1,550	
Repairs and maintenance of buildings, feu duty, &c.	934	
		2,484
3. New Glasgow University—to assist in erection of		20,000
4. Industrial Museum, Edinburgh—		
Maintenance	£2,028	
For extension of	10,000	
		12,028
5. Privy Council grants to elementary schools		86,170
6. Her Majesty's charities and bounties		2,400
7. Historical records, publication of		1,000
8. Rent of Royal Society's apartments		300
9. Fishery Board (for branding, building harbours, &c.)	£13,312	
Deduct brand fees collected by board, and remitted to Imperial Treasury	4,705	
		8,607
10. Portpatrick harbour		82
		£149,795

NOTE.—There is a sum of about 1,140*l.* yearly, paid for the maintenance of the National Gallery of Scotland, and a sum of 300*l.* yearly, paid for the maintenance of the Government Archæological Museum. These sums not being drawn from the Imperial Treasury, are not included in the above list. They are paid by the Board of Trustees for Scottish Manufactures and Improvements, from funds which belong to Scotland proper, viz., a fund of 2,000*l.* a year, which, by the Treaty of Union, was appointed to be paid for ever to Scotland, in respect of increased duties then laid upon Scotland for customs and excise.

II.—IN IRELAND.

1. Royal Dublin Society (*agriculture, &c.*)—		
Maintenance	£2,235	
New works	2,417	
		£4,652
2. Royal Irish Academy (*science, literature, and antiquities*)—		
Maintenance	£2,390	
New works	85	
		£2,475
3. Irish Academy of Music		70
4. Royal Hibernian Academy (*fine arts*)		300
5. National Gallery of Ireland (*pictures*)		2,393
6. Dublin Library		1,502
7. College of Science (*science and art*)		8,177
8. Botanic Gardens—		
Dublin	£2,201	
Glasnevin	863	
		£3,064
9. Museum of Natural History		1,615
10. Royal Zoological Society (*birds and beasts*)		500
11. Agricultural model schools		
Maintenance	£7,375	
New works	4,516	
		11,891
12. Flax cultivation		2,000
13. Leinster lawn		855
14. Public or national education (*primary schools*)		481,897
15. National education buildings		8,302
16. Ordinary literary schools		3,225
17. Queen's Colleges—		
Maintenance	£5,920	
New works	290	
		6,210
18. Queen's University		3,224
19. Hospitals in Dublin and Kilmainham		19,114
20. Lunatics and foundlings		1,540
21. Harbours		10,976
22. Fishery piers		4,526
23. Inland navigation		5,454
24. Miscellaneous charitable allowances		6,324
25. Phœnix Park		6,315
26. Curragh of Kildare		830
27. Queen's plates		1,562
		£598,993

APPENDIX XV. (See Questions **12,535–12,538,** Vol. II. pp. 260, 261.)

PETITION of the COUNCIL of the GEOLOGICAL SOCIETY of EDINBURGH.

UNTO THE HONORABLE THE ROYAL COMMISSIONERS ON SCIENTIFIC INSTRUCTION AND THE ADVANCEMENT OF SCIENCE.

The Petition of the Council of the Geological Society of Edinburgh,

Humbly sheweth,—

That the Geological Society of Edinburgh was instituted in the year 1834, and now numbers 208 members, comprising one patron, 13 honorary fellows, 62 foreign corresponding fellows, 115 ordinary fellows, and 17 associates.

The annual income of the Society is estimated at 80*l.* The annual expenditure is as follows:—Rent of Society's library and museum, 21*l.*; printing billets, 6*l.*; books purchased, 5*l.*; allowance to assistant librarian, 2*l.* 2*s.*; allowance to secretary's clerk, 10*l.* 10*s.*; sundries and insurance, 6*l.*; publishing Society's "Transactions," 40*l.*; total, 90*l.* 12*s.* There is thus an apparent deficit of 10*l.* 12*s.*, which can only be avoided by not publishing Transactions, a course very fatal to a scientific society, as tending to make scientific men unwilling to read papers before it, and thus depriving its meetings of interest, and its members of instruction.

The annual subscription of members is fixed at the low rate of 12*s.* 6*d.*, a sum which enables persons of small means, and artisans desirous of acquiring a knowledge of the science of geology, to join the Society, and the fact that some of the most active members of the Society belong to the artisan class, proves how much a knowledge of geology is appreciated by them, and is capable of being developed by the Society. The Society's geological library and museum are open all day to members, and are much taken advantage of by them.

At the same time, the Society has always had to struggle with pecuniary difficulties. After publishing three volumes of its Transactions (copies of which are submitted herewith to the Commissioners), it found itself considerably involved in debt. Indeed, to enable it to publish the current fourth part of its Transactions, it was compelled to resort to a private and special subscription among its more wealthy members. The sum thus raised amounted to 40*l.*, but the subscriptions were given on the understanding that they were never to be solicited for a similar purpose again.

It is now humbly submitted that if the Society received an annual grant from Government of 50*l.*, this would enable it not only to publish its Transactions, but also to exist without incurring debt, to increase its present small library and museum, and to acquire better accommodation for its meetings.

May it therefore please your honorable Commission to take the premises into consideration, and to report favourable as to a grant of 50*l.* being made by the State to the Geological Society of Edinburgh, so that it may be enabled to advance the science of Geology in the city of Edinburgh and district.

Signed on behalf of the Council by the President of the Society, of date 14th June 1872, and authorized to be presented by the Vice-President of the Society, David Milne-Home, Esq., of Wedderburn, LL.D., F.R.S.E., F.G.S.

(L.S.) ARCH. GEIKIE, President.

APPENDIX XVI.

LETTER from the Honourable Mr. JUSTICE GROVE, F.R.S.

115, Harley Street,
June 17, 1872.

DEAR MR. LOCKYER,

I HAVE been thinking over our conversation, and as I do not wish to shrink from expressing my opinions, I put them on paper for the Commission, premising that I have very little time to think at all. I agree with Colonel Strange that physical and experimental science is not assisted by Government proportionately to other branches of science. While the British Museum for natural history, the Greenwich Observatory for astronomy, the Jermyn Street Institution, and others, are aided by Government, scarcely anything is done for that most important department of science, inorganic physics and experimental research; and yet, whether we view it in its effects upon practical human progress or upon enlarged knowledge of the universe, no branch is more valuable. Railways, electric telegraphs, &c., may be cited under the former head; the discovery of the constituents of planets and stars and of their motion in space under the latter.

I think physical and chemical laboratories with proper apparatus might be supported by Government or with Government aid, to the great advantage of the nation and of science.

I do not agree with Colonel Strange or Sir W. Thomson as to their views of a large or highly paid permanent Scientific Council to advise the Government. It would, in my humble judgment, take away from more useful work the best producing power.

It would sink our great scientific men in the slough of administrative work; it would lead to political intriguing for place; and not the best men of science, but the ablest men of the world would succeed.

Scientific men, moreover, are not, as a body, suited for the work; it requires great practice and habit, in short a special education.

With regard to pecuniary remuneration, it should be always borne in mind that if Adam Smith's proposition be true, that professions and trades are lucrative in proportion as they are disagreeable, the cultivation of science, being most agreeable, can hardly be expected to be highly lucrative, I mean its cultivation for itself or for research and not for the promotion of profitable inventions which have in them as much of art as of science.

There is another reason why the pursuit of science is not, in my judgment, likely to be highly paid. The benefits resulting from it are future and not present. A man will pay highly to a physician to save the life of a wife or a child, or to a lawyer to prevent the loss of an estate, but he will not contribute largely for advantages to be enjoyed by future generations, and as to which the probability of practical success is generally doubtful, and can only be ascertained after a lapse of time.

What is true of the individuals is, *mutatis mutandis*, true of Government support, and we see this pointedly in the fact that the inventions which are most speedily taken up by Governments are destructive engines of war, the results of improvement in them being of a more immediate character than those proceeding from the discovery of a new phenomenon or a new generalization.

There is also an objection to Government patronage, that it is apt to lead to *schools* of science: we have most of us heard complaints in those countries where there are academies or institutions the membership of which give a high position and which command the entrances to professorships, that young men are rather deterred than encouraged in the advancing of original views, as these generally clash with the ideas and detract from the reputation of the older scientific men who hold the keys to preferment in their hands.

Notwithstanding all this, I think more can and ought to be done than is done in this country, and although I had, as you may remember, great difficulty in seeing how a more unambitious scheme than those I have alluded to might be framed, I have, since our interview, read General Strachey's paper, and his proposal seems to me the most hopeful—a continuation of the present Commission, permanent as a body, but changed as to individuals.

I would not have it, as he proposes, indefinite in number; it would then be impossible to resist pressure or immediate wants, and the body would soon be so diluted as to be valueless. Ten or twelve members would be amply sufficient, of which one-fifth or one-fourth should retire annually, and not be re-eligible for a year or two.

I do not see why the members should not be paid a reasonable salary for their time and trouble, but I would not put this too high, because, if obtained, it would lead to the political-interest-making system to which I have alluded; and, secondly, which, perhaps, may be a more conclusive reason, because you won't get it. I am not very sanguine as to the working of such a council, but I think the experiment worth trying. I also agree with General Strachey as to the desirability of reorganizing the existing scientific societies; it would save much useless expense, lead to more co-operation, and promote more discipline in scientific workers, so that work in common for definite purposes might take the place of disjointed efforts. These hasty ideas I send you, hardly hoping that they may be of service to the Commission; but not liking, as it has done me the honour of asking my opinion, to avoid the responsibility of giving it for what it is worth.

Yours very faithfully,
W. R. GROVE.

APPENDIX XVII.

SCIENTIFIC INSTRUCTION in GERMANY.

COMMUNICATION from PROFESSOR HOFMANN, F.R.S.

10, Dorotheenstrasse, Berlin,
July 21, 1870.

DEAR SIR,

UPON receipt of your note dated July 8, I have immediately endeavoured to procure the information which the Royal Commissioners desire to obtain. The peculiar administration of educational affairs in Prussia renders this task difficult at all times, but more especially at the present moment, when, in consequence of the war, the staff of all government offices is reduced to a minimum, and, moreover, taxed to the very limit of their capabilities.

To render this intelligible you must allow me some explanatory remarks.

The Minister of Education, who is at the same time Minister of Public Worship and of Medical Affairs (*Minister der geistlichen Unterrichts und Medicinal Angelegenheiten*), has the direction of the universities, and of the preparatory, classical, and technical schools (*Gymnasien* and *Realschulen*).

The Minister of Commerce (*Handels-Minister*) has charge of the higher technical institutions (*Gewerbe-Akademien, Bau-Akademien, Berg-Akademien* and *Polytechnische Schulen*).

The schools for foresters (*Forst-Akademien*) are in the hands of the Chancellor of the Exchequer (*Finanz-Minister*).

Lastly, the Minister of Agriculture (*Minister für landwirthschaftliche Angelegenheiten*) takes care of the agricultural institutions (*landwirthschaftliche Lehr-Anstalten*).

This divided administration of educational affairs has many disadvantages, and the question has been often discussed, whether it would not be desirable to unite all the educational establishments under one head. Up to the present moment, however, the division subsists, and certainly it presents also many good points.

On the present occasion, however, it has prevented me from procuring all the information which the Royal Commission requires. Indeed, as yet, I have only got some reliable notes from the Ministry to whom I myself belong.

Whatever can be of interest to the Commissioners with reference to the funds provided for the Prussian *Universities*, you will find in the memorandum which I send with this note. The figures it contains you may rely upon; they were supplied to me by *Dr. Olshausen*, the chief of the Department of Universities in the Ministry. The table refers to the year 1869. The same information respecting the *gymnasiums* and the *preparatory technical schools*, I find is admirably collected in a Synopsis given in *Wiese's* remarkable work on Education in Prussia, a copy of which I have forwarded to you yesterday by post; Comp. vol. I. p. 606. I first intended to send you a written copy of the Synopsis only, but, on consideration, I thought that the book itself, which is really remarkable for the variety and accuracy of the data it supplies, might be of use to the Commissioners. The copy which I forward belongs to a friend of mine: you will therefore return it to me after you have made use of it. But as matters stand at present, there is very little probability of my friend requiring it during the next six months.

I remain, &c.

Norman Lockyer, Esq. A. W. Hofmann.

P.S. At this moment your letter dated July 19th reaches me. It will give me much pleasure if, after the recess, I can manage, in conformity with the wishes of the Royal Commission, to come to London. But I do not venture to make any promise for so long a period. We must first settle our accounts with the French.

No.	Universities.	Income.														
		By Government Grants.			By Endowments and Funds left for Special Purposes.			By Interest of sums invested and Revenue from Landed Property.			By Matriculation Fees.			Sum Total.		
		Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.
1	Berlin	213,667	24	3	50	0	0	111	0	0	7,854	5	9	221,683	0	0
2	Breslau	101,276	0	0	—			13,167	25	6	2,958	4	6	117,402	0	0
3	Bonn	144,477	7	6	183	0	0	3,250	10	9	3,461	19	3	151,372	7	6
4	Halle	75,431	15	0	44,127	0	3	667	7	6	7,259	22	3	127,485	15	0
5	Königsberg	111,351	23	5	40	0	0	4,043	6	8	1,996	29	11	117,432	0	0
6	Griefswald	—			57	0	0	92,952	0	0	1,091	0	0	94,100	0	0
7	Münster	2,250	0	0	18,576	0	0	—			1,550	0	0	22,376	0	0
8	Göttingen	42,651	7	1	130,939	20	6	3,139	2	5	5,200	0	0	181,930	0	0
9	Marburg	79,200	0	0	742	29	4	15,486	3	8	1,050	27	0	96,480	0	0
10	Kiel	89,356	0	0	504	0	0	5,134	20	0	226	12	0	95,221	2	0
	Sum total	859,661	17	3	195,219	20	1	137,951	16	6	32,649	0	8	1,225,481	24	6
								365,820	7	3						

continued.

No.	Universities.	Expenditure.																				
		Administration of Universities.			Salaries of Professors and Lecturers.			University Institutions, University Collections, and Religious Worship in the Universities.			Grants for Prizes and Scholarships.			Building Expenses and Taxes.			Office Expenses.			Sum Total.		
		Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.	Th.	sbg.	pf.
1	Berlin	11,541	0	0	107,400	0	0	88,907	29	9	350	0	0	2,000	0	0	11,484	0	3	221,683	0	0
2	Breslau	7,869	0	0	57,830	15	0	35,837	10	6	5,641	15	0	6,000	0	0	4,223	19	6	117,402	0	0
3	Bonn	8,789	0	0	85,194	0	0	43,532	22	6	3,300	0	0	6,159	9	6	4,397	5	6	151,372	7	6
4	Halle	7,600	0	0	57,597	0	0	43,080	17	5	7,956	0	0	6,246	0	0	5,005	27	7	127,485	15	0
5	Königsberg	7,001	16	8	47,832	15	0	41,188	15	0	9,494	5	5	4,414	13	0	7,500	24	11	117,432	0	0
6	Griefswald	4,222	8	0	45,875	0	0	37,265	3	9	3,726	0	0				3,011	18	3	94,100	0	0
7	Münster	430	0	0	15,000	0	0	5,435	0	0	500	0	0	—			1,011	0	0	22,376	0	0
8	Göttingen	14,245	5	0	85,377	0	0	60,325	17	2	13,140	21	5	5,100	0	0	5,741	16	5	181,930	0	0
9	Marburg	6,397	12	6	50,185	12	8	24,431	2	1	4,508	16	10	8,541	22	1	2,415	23	10	96,480	0	0
10	Kiel	4,396	0	0	57,660	0	0	26,118	2	0	504	0	0	3,800	0	0	2,743	0	0	95,221	2	0
	Sum total	70,491	12	2	609,951	12	8	406,122	0	2	49,120	28	8	42,261	14	7	47,534	16	3	1,225,481	24	6

ANALYSES OF EVIDENCE.

LIST.

Page
Analyses of Evidence respecting the Universities of Oxford and Cambridge - *75–132*
Analyses of Evidence respecting the National Scientific Museums and Collections *133–144*
Analyses of Evidence respecting the Universities of London and Durham - *145–149*
Analyses of Evidence respecting University College and King's College, London, and Owens College, Manchester - - - - - - *150–163*
Analyses of Evidence respecting the Scotch and Irish Universities - - *164–187*
Analyses of Evidence respecting the Advancement of Science - *188–210*
Analysis of Evidence respecting the Standards' Department of the Board of Trade - - - - - - - - - *211, 212*

ANALYSES OF THE EVIDENCE

RESPECTING THE

UNIVERSITIES OF OXFORD AND CAMBRIDGE,

REPORTED ON IN THIRD REPORT.

University of Oxford.

ACLAND, HENRY WENTWORTH, Esq., M.D. (Index of his Evidence.)

Accommodation for Science Purposes.
Foundation of Museum of Oxford, with lecture rooms, laboratory, &c., 2879–2884, 2905–2912, 2932, 2948, 2949, 2953–2963.

Anatomy. See *Biology.*

Apparatus for Science Purposes.
Typical illustrations (like Mr. Robertson's dissections of animals, exhibited in the Great Exhibition) might be prepared for the principal schools; this might be done at Oxford, 2966–2970.
The principle of sending out art specimens, adopted at South Kensington, might be well followed with respect to science specimens, 2970.

Assistant Professors.
Want of assistant professors at Oxford University, 2916–2919.
Assistant professors at Oxford should be appointed only under a central administration, 2932–2935.
Persons like the German extraordinary professors would be most desirable at Oxford; they might be appointed for four or five years, and be part of the museum administration, 2941–2946.

Biology.
Physiological science at Oxford in 1845; was not recognized by University; anatomy and physiology were only taught then at Christ Church College, 2874–2880, 2934.
Extension of physiological teaching at Oxford, foundation of Museum, 2879–2883.
The term biology now represents what was formerly meant by physiology, 2880.
For degrees at Oxford, chemistry and physics might be taken, but a knowledge of biology is desirable, 2895–2898.
Lee's readership of anatomy at Oxford not recognized as a professorship, 2906, 2934.
Grants made by Radcliffe trustees at Oxford, for microscope and histological demonstrations, 2913.
Oxford students of physiology; number in laboratories of Sir Benjamin Brodie and Professor Rolleston, 2948, 2949.
Mr. Robertson's animal dissections, for teaching in schools; similar typical sets might be furnished under proper supervision, 2970.
See *Physiology.*

Botany.
Botany could be taught with advantage to boys in schools, 2897.

British Museum.
Typical examples of external forms, for educational purposes, might be obtained from the British Museum, &c., 2967.

Buckland, Dr.
Dr. Buckland declined to assist in formation of Oxford museum, to which his collection was transferred, 2880, 2912.
Excursions for practical instruction in geology formerly superintended by Dr. Buckland, 2886.

ACLAND, Dr.—cont.

Chemistry.
Chemistry and physics alone might be taken for degrees at Oxford, but a knowledge of biology is desirable, 2895–2898.

Children.
Boys in schools might be taught botany with advantage, 2897.

Christ Church College (Oxford).
In 1845, the only place in Oxford for teaching anatomy and physiology was Christ Church, 2880.
Practical class in anatomy and physiology formerly held at Christ Church; stopped as illegal, 2881.
The Christ Church collection of anatomy and physiology was transferred to Oxford museum, 2912.

Classics. See *Literature.*

Cost of Scientific Instruction.
Cost of Oxford Museum defrayed by the University, 2903–2905, 2907.

Coutts, Miss Burdett.
Geological scholarship at Oxford founded by Miss Burdett Coutts; the holder should reside in the University, 2943.

Degrees.
Chemistry and physics alone might be taken for degrees at Oxford, but a knowledge of biology is desirable, 2895–2899.
The science degree should be separated from the arts' degree at Oxford, but the holder should have had a proper amount of arts' culture; examinations should be practical, 2900–2902.
Oxford science degrees are, nominally, degrees in arts, 2936–2940.

Dissections.
Dissections of animals for teaching in schools, exhibited by Mr. Robertson in the Great Exhibition, 2966.

Education.
The great centres of education must provide teachers for the scientific instruction in schools proposed by Endowed Schools' Commission, 2928, 2929.

Endowed Schools' Commission.
For the science teaching in schools prescribed by Endowed Schools' Commission, the great centres of education must provide teachers, 2928, 2929.

Examinations.
Test by examination is good, but it should show the steps by which the answers have been reached, 2901.
The subjects of examination on entering the University from the public schools should be settled by authority 2940.

Fellowships. See *Scholarships, Fellowships, &c.*

Geology.
Dr. Buckland's geological collection was transferred to the museum of Oxford, in the formation of which he had declined to assist, 2880, 2912.
Interesting geological excursions of Dr. Buckland, 2886.

German Universities.
Professors like the German extraordinary professors would be desirable for Oxford University, 2941.

ACLAND r.—cont.

Grants for Science Purposes.
Oxford University grants for building Museum, 2881, 2903–2905.
Grants should be made to university professors for pursuing original research, 2913.
Grants for microscope and histological demonstrations made by Radcliffe trustees at Oxford, 2913.

Great Exhibition.
Dissections of animals for educational purposes shown by Mr. Robertson in the Great Exhibition, 2966–2970.

Greek.
The study of Greek should not be made compulsory on members of the medical profession, 2973, 2976.

Laboratories.
Oxford Museum laboratories are not endowed, but are supported by occasional grants; accommodation therein, 2910, 2911, 2948, 2949.

Laboratories (Biological).
Number of students in the laboratories of Sir Benjamin Brodie and Professor Rolleston, 2948, 2949.

Lectures.
At Oxford, each professor has to give a prescribed number of lectures, but the regulations are various; great latitude is given, 2916–2919.

Leeds.
Importance of a science college in such a centre as Leeds, 2924, 2925.

Lee Readerships (Oxford).
Lee readerships at Oxford; not recognized as professorships; formerly but one, now there are three, viz., of anatomy, physics, and chemistry, 2906, 2934.

Literature.
A particular fellowship is thrown open to classics at Oxford, 2906.
No difficulty in science and literature going on together in the same school, 2974.

Manchester.
Importance of a science college in such a centre as Manchester, 2925.

Mathematics.
A particular fellowship is thrown open to mathematics at Oxford, 2906.

Medicine.
Universities should give a thorough training for entering into schools of medicine, 2920–2922.
Desirable if instruction in comparative pathology, and experiments in therapeutics and materia medica, could be given in Oxford University, 2942.
The study of Greek should not be made compulsory on members of the medical profession, 2973, 2976.

Museum of Oxford. See *Oxford University.*

Newcastle.
Importance of a science college in such a centre as Newcastle, 2925.

Original Research.
Opportunities of pursuing original research should be given to Oxford professors; grants should be made to them for that purpose, 2893, 2915.
Professors occupied in original research should not be compelled to teach, 2914.
The residence at Oxford of men engaged in original research, would give a great stimulus to work, 2947.

Oxford.
Populations of Oxford and the north contrasted, with respect to the influence of scientific institutions, 2924–2927.

Oxford University.
Extension of scientific studies at Oxford since 1845; increase of biological teaching, 2877–2977.
Museum of Oxford; foundation; transference of Radcliffe Library to same; cost of building, &c.; should be the recognised head of the university scientific department, 2879–2881, 2905–2912, 2932, 2948, 2949, 2953–2963.
University students; their love of science; appointments; examinations; training, as a foundation for the medical profession, number accommodated in teaching apparatus of museum, 2888–2892, 2895–2897, 2900–2902, 2906, 2920–2923, 2936–2940, 2948, 2949.
Great change of opinion in the university respecting scientific studies; physical science now as much a study as any other subject, 2885–2889.

ACLAND, Dr.—*Oxford University*—cont.
Well-trained scientific students at Oxford always get appointments as teachers in colleges, &c.; superior science teachers should be the outcome of the Oxford museum, 2890–2892, 2924–2927.
Oxford professors should pursue original research, and have grants for the purpose; this would stimulate work in the university, 2893, 2913, 2947.
Approval of present system of Oxford University natural science schools, 2895.
University degrees; chemistry and physics alone might be taken, but knowledge of biology desirable; science degree should be separated from arts' degree; examinations should show how answer was attained, 2895–2902, 2936–2940.
Classical, mathematical, and physical fellowships in the university are all separate fellowships, 2906.
Lectures at the university; number prescribed, but regulations very various, 2916–2919.
The education at Oxford should lay a thorough foundation for entrance into the medical profession, 2920–2922.
Assistant professors (like the German extraordinary professors) most desirable for the university, 2941–2947.
Miss Burdett Coutts's geological scholarship at Oxford; loss to university from holder not being obliged to reside there, 2943.
Technical education at the university undesirable, 2950.
Typical illustrations for teaching in schools (as dissections, &c.) might be prepared at Oxford, 2966–2970.

Physics.
Chemistry and physics alone might be taken for degrees at Oxford, but a knowledge of biology is desirable, 2895–2898.
At Oxford, a particular fellowship is thrown open to physics, 2906.

Physiology.
Physiology was the term formerly used for what is now called biology, 2880.
See *Biology.*

Practical Instruction.
Interesting excursions for practical geological teaching formerly undertaken by Dr. Buckland, 2886.
Practical work is now a special characteristic of the scientific teaching at Oxford; accommodation in museum laboratories, &c., 2886, 2948, 2949.

Professors.
A class of thoroughly trained teachers of physical science should be the outcome of the Oxford Museum; instances of such teachers cited, 2890–2892.
Professors should pursue original research, and have grants for that purpose; and should be permitted to teach or not, at will, 2893, 2914.
At Oxford the professors give a prescribed number of lectures; the regulations are various; great latitude is allowed them, 2916–2919.
Assistant professors wanted at Oxford; extraordinary professors, as in Germany, most desirable; they might be appointed for four or five years, and be part of the museum administration, 2916–2919, 2941–2946.
For the increased scientific teaching proposed by the Endowed Schools' Commission, the great centres of education must provide worthy teachers, 2928, 2929.
See *Oxford University.*

Professorships.
There are ten professorships in Oxford Museum, 2912.
Extension of professorships in universities should only be effected under a central administration, 2932–2935.

Radcliffe Library (Oxford).
Transference of the library to Oxford Museum; it is open to the city and county, as well as to the university; not well attended; great facilities given in it to students, 2881, 2882, 2907, 2977.
See *Oxford University.*

Scholarships, Fellowships, &c.
Classical, mathematical, and physical fellowships at Oxford; all separate fellowships, 2889, 2906.
Geological scholarship at Oxford founded by Miss Burdett Coutts; holder should be resident, 2943.

Schools.
Boys in schools might be taught botany with advantage, 2897.
The schools proposed by the Endowed Schools' Commission must be supplied with teachers from the great centres of education, 2928, 2929.
Special examinations essential in entering universities from public schools, 2940.

ACLAND, Dr.—*Schools*—cont.

A scientific department should be attached to public schools, 2964.

General training in schools is more important for boys than a particular application of science, 2965.

Typical illustrations, as dissections, &c., might be prepared, under proper supervision, for the principal schools, 2966–2970.

The time is come when, in a first-class school, boys, at some period, should go through the science department, 2971–2973.

No difficulty in combining literary and scientific instruction in the great public schools, 2974–2976.

Science.

Science teaching at Oxford; its extension; favourable change of opinion respecting it, &c., 2877–2977.

The elements of botany could be taught with advantage to boys in schools, 2897.

Want of sympathy of physicists and chemists with biologists, 2898, 2899.

The science degree should be separated from the arts' degree, 2900.

Large schools should have a scientific department attached to them, 2964–2976.

For boys in schools, a general training is more important than a particular application of science, 2965.

No difficulty in science and literature going on in the same school, 2974.

See *Original Research.* *Oxford University.*

Science Colleges.

Importance of science colleges in such centres as Leeds, Newcastle, Manchester, &c., 2925.

Science Teachers. See *Professors.*

South Kensington.

The South Kensington principle of sending out art specimens might be followed with respect to illustrations for science teaching, 2970.

Students.

Boys in schools could be taught botany with advantage; a general training for them more important than particular application of science, 2897, 2965, 2971–2973.

There should be special examinations for students entering universities from public schools, 2940.

See *Oxford University.*

Technical Instruction.

Not desirable to give technical instruction at Oxford University, 2950.

Universities.

The colleges of the universities will probably in future devote funds to increase their scientific instruction, 2930–2932.

New professorships or assistant professorships in universities should be founded only under a central administration, 2932 2935.

There should be a special examination on entering the universities from public schools, 2940.

See *Oxford University.*

CLIFTON, ROBERT BELLAMY, Esq., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.

New building erected at Oxford for teaching physics, 2981–2987, 2999.

Age of Science Students.

Children of 12 years and upwards might have very elementary instruction in science; but systematic instruction should be postponed, 3094–3096.

Apparatus for Science Purposes.

Apparatus for teaching physics at Oxford; grants for the same, 2984–2987, 2990, 2996.

Assistant Professors.

Appointment of a demonstrator in the physical laboratory at Oxford, 2988, 2990.

For promotion of original research, skilled assistants to professors are wanted at Oxford; assistants, as well as professors, might undertake research, 3024–3026, 3050–3054.

Great care should be taken in appointment of assistant professors, 3027.

At Oxford, there might be subordinate lecturers lecturing under the University professors, 3047.

A considerable staff of assistant professors will probably be wanted at Oxford; provision for these might be made by re-distribution of the fellowship funds, 3077–3087.

Buildings for Science Purposes. See *Accommodation for Science Purposes.*

CLIFTON, R. B., Esq.—cont.

Chemistry.

Physics, chemistry, and physiology are the principal sciences recognised in the natural science school at Oxford, 2979.

Examinations in chemistry at Oxford are in part practical, 3000.

Mechanics and chemistry desirable subjects for the early training of boys, 3056, 3057.

Children.

Mechanics should be studied before physics by boys; mechanics and chemistry might be combined, 3056, 3057.

Boys in schools might be classified according to natural power, but their instruction must not be one-sided, 3058–3061.

No harm in instructing children in the elements of science; but systematic instruction of that kind should be postponed, 3094–3096.

Christ Church College (Oxford).

Provision for teaching science at Christ Church College, 2997.

Classics. See *Literature.*

Contributions for Science Purposes. See *Grants for Science Purposes.*

Cost.

Cost of new building and apparatus for teaching physics, at Oxford, 2984–2986.

Cramming.

Not always a fault of teaching; often due to attempting too much, and to insufficient appliances, 3065, 3066.

Degrees.

Oxford University degrees; proportion of graduates in natural science, 3039, 3040.

Endowed Schools' Commission.

In schools like those proposed by Endowed Schools' Commission, boys might be classified as to natural power, but with care; scientific scholarships should be available for these schools, 3058–3061, 3090.

Examinations.

Physics, chemistry, and physiology are the chief subjects of examination in the natural science school at Oxford; other sciences may be optionally introduced, but only in addition, 2979.

Science examinations at Oxford are in part practical, 3000–3004.

Earlier university examinations in classics and mathematics desirable; or a knowledge of science might be offered as an alternative for part of them, 3011–3015.

Science in schools would be promoted by elementary science examinations at Oxford, 3013–3015.

Examinations for scientific scholarships at Oxford should be restricted to ensure thorough teaching in schools, 3019.

Cramming for examinations not always a fault in teaching; may be due to attempting too much, with imperfect appliances, 3065, 3066.

No preliminary examination for physics' class at Oxford, 3074, 3088.

The multiplication of examinations is an evil, 3088.

Fellowships. See *Scholarships and Fellowships.*

Grants for Science Purposes.

Grants for demonstrator, apparatus, laboratory, &c. for teaching physics at Oxford, 2986, 2987, 2990–2996, 3045.

Necessity of the colleges at Oxford providing funds for extension of science teaching, 3017, 3018.

Laboratory (Physical).

Physical laboratory at Oxford; new building; demonstrator; system of instruction; grants; students; separate accommodation for carrying on research, &c., 2981–2996, 2999, 3005, 3007, 3025, 3045, 3054, 3075–3078, 3093.

Lecturers.

Science lecturers at Oxford; interchange of lecturers between different colleges, 2997, 2998, 3046, 3047.

See *Professors.*

Lectures.

Lectures on physics at Oxford University; two courses, 3071–3076, 3046, 3047.

Literature.

Earlier University examination in classics and mathematics, or scientific knowledge allowed as an alternative for part of the course, would be desirable, 3011–3015.

CLIFTON, R. B., Esq.—cont.

Magdalen College (Oxford).
- Provision for teaching science in Magdalen College; interchange of lecturers with Merton and Wadham, 2997.

Mathematics.
- Earlier university examinations in classics and mathematics, or scientific knowledge allowed as an alternative for part of the course, would be desirable, 3011–3015.
- Evil of studying physics without a foundation in mathematics, 3062–3064.

Mechanics.
- In the training of boys, mechanics should be studied before physics, and be combined with chemistry, 3056, 3057.
- Physics should not be studied without a foundation in mechanics, 3062–3064.

Merton College (Oxford).
- Provision for teaching science in Merton College; interchange of lecturers with Wadham and Magdalen, 2997.

Original Research.
- The increased means for teaching physics at Oxford may enable students to do original work, 2999.
- Original research is one of the main functions of Oxford University; professors must be relieved to effect this, 3022–3027, 3048–3054.
- Oxford fellowship funds might be made available for scientific research, 3032, 3033.

Oxford University.
- Teaching of physics at Oxford; new laboratory, apparatus, &c.; cost; lectures, &c., 2978–2996, 2999, 3005, 3007, 3025, 3045, 3054, 3071, 3075–3078, 3093.
- There are three University teachers of physics; one being a demonstrator, for giving practical instruction in the laboratory, 2988, 2990, 3077, 3078.
- Science lecturers at Oxford; interchange of lecturers between different colleges, 2997, 2998.
- Colleges at Oxford; provisions for teaching science; colleges must co-operate with University for extension of scientific teaching; college scholarships, as well as University scholarships, desirable, 2997, 2998, 3016–3020, 3046, 3047.
- Only four colleges at Oxford (viz., Christ Church, Wadham, Merton, and Magdalen) appear to have proper provision for teaching science, 2997.
- Students of physics at Oxford; instruction; enter for different objects, but majority for teachers; remain about three years; number slightly increases, but quality greatly improves; suggestions for increasing the number, 2999, 3005–3012.
- Examinations in science at Oxford are both written and practical; advantage if University examined in elementary science; no preliminary examination for physics' class, 3000–3004, 3013–3015, 3074, 3088.
- Original research is one of the main functions of the University; to effect this professors must be relieved in teaching; fellowship fund might be made available, 3022–3027, 3032, 3033, 3048–3054.
- Oxford professors; appointed by different boards; professors should form the nucleus of these boards; their remuneration should equal a profession; they should have pensions, 3028–3031, 3067–3070.
- Fellowships at Oxford; 10 only for natural science; the scientific fellows are not required to teach, 3032–3041.
- University degrees; proportion of graduates in natural science, 3039, 3040.
- The University should not give technical instruction, 3042.
- The usefulness of Oxford University might be increased by allowing men to study in affiliated colleges, and pass their last year in the University, 3043, 3044.
- Of the former students at Oxford, some are fellows and teachers in the colleges, and others teachers in large public schools, 3099.

Pensions. See *Superannuation.*

Physics.
- Provision for teaching physics at Oxford; new physical laboratory, &c., 2978–2996, 2999, 3005, 3007, 3025, 3045, 3054, 3075–3078, 3093.
- Physics, chemistry, and physiology are the chief sciences in the Oxford University natural science school, 2979.
- Three University professors of physics at Oxford; one for giving practical instruction, 2988, 2990.
- Examinations in physics at Oxford are in part practical, 3000–3004.
- In the training of boys, mechanics should be studied before physics, 3056, 3059.

CLIFTON, R. B., Esq.—*Physics*—cont.
- Evil of studying physics without a foundation in mathematics and mechanics; defects of science-school teaching in this respect, 3062–3064.
- No preliminary examination for physics' class at Oxford, 3074.

Physiology.
- Physics, chemistry, and physiology are the principal sciences recognised in the natural science school at Oxford, 2979.
- Examinations in physiology at Oxford are in part practical, 3000.

Practical Instruction.
- Practical instruction in the physical laboratory at Oxford, 2988–2991, 2999.
- In the science examinations at Oxford practical knowledge has to be shown, 3000–3004.

Professors.
- At Oxford, there are three university professors of physics; one a demonstrator in the physical laboratory, 2988.
- Science lecturers at Oxford; interchange of lecturers between different colleges, 2997, 2998.
- To promote original research at Oxford, professors must be relieved in teaching, 3022–3027, 3048–3054.
- Oxford professors; appointed by different boards; remuneration should equal a profession; should have assistant professors; should have pensions, 3025–3031, 3067–3070, 3079–3081, 3084, 3087.

Professorships.
- Undesirable to have professorships at Oxford for terms of years, 3082, 3083.

Scholarships and Fellowships.
- More scholarships and fellowships are needed to increase the number of scientific students; examinations should be restricted to ensure thorough teaching in schools, 3011–3020, 3055, 3088, 3089.
- Desirable to have both college and university scholarships at Oxford, 3019, 3020.
- Oxford fellowship fund might be made available for scientific research, assistant professors, &c., 3032, 3033, 3040, 3081, 3084, 3086.
- Of the 372 fellowships at Oxford, 10 only are for natural science; a large proportion can only be given to clergymen; holders of scientific fellowships are not required to teach; difficult to connect tenure of fellowships with teaching, 3034–3041, 3079, 3087.

Schools.
- Necessity of science being taught in schools; the teaching should be thorough, and not extensive; scholarships should be available, 3011–3020.
- Scientific instruction in schools might be promoted by elementary science examinations at Oxford, 3013–3015, 3055.
- Mechanics and chemistry should precede physics as studies at school, 3056, 3057.
- Boys in schools might be classified as to particular abilities, but their instruction must not be one-sided, 3058–3061.
- Systematic scientific instruction should not be given to young children in schools, 3094–3096.

Science.
- Necessity of science being really introduced into schools; scholarships should be available, 3011–3020, 3055, 3088, 3089.
- Science in schools would be promoted by elementary science examinations at Oxford, 3013–3015, 3055.
- Science applied to industries should not be taught in universities, 3042.
- Cramming not always a result of imperfect teaching of science; too much may be attempted, with insufficient appliances, 3065, 3066.
- Systematic scientific instruction should not be taught to young children in schools, 3094–3096.

See *Chemistry, Physics, &c.*

Science Schools.
- Defective teaching of physics in science schools, 3064.

Science Teachers. See *Professors.*

Students.
- Students of physics at Oxford; instruction; mostly study to become teachers; a superior class of men attend now, 2999, 3005–3012, 3039, 3040, 3062–3064.
- To increase the number of scientific students, there should be science-teaching in schools, scholarshipshand fellowships, and earlier examinations in classics and mathematics, 3011, 3012, 3019, 3055, 3088, 3089.

CLIFTON, R. B., Esq.—*Students*—cont.

Boys in schools should study mechanics and chemistry before physics; boys might be classified as to ability, but their instruction must not be one-sided, 3056–3061.

No preliminary examination for students in physics' class at Oxford, 3074, 3088.

Very elementary science might be taught to children, but systematic instruction of that kind should be postponed, 3094–3097.

Of the former students at Oxford, some are fellows and teachers in the colleges, and others teachers in large public schools, 3099.

Superannuation.

Oxford professors should have pensions; there are none at present, 3030, 3031.

Technical Instruction.

Technical instruction should not be given at universities, 3042.

Universities.

Universities should not give technical instruction, but should train for the professions, 3042, 3043.

Wadham College (Oxford).

Provision for scientific teaching in Wadham College; interchange of lecturers with Merton and Magdalen Colleges, 2997.

PHILLIPS, JOHN, Esq., M.A., F.R.S. (Index of his Evidence.)

Apparatus for Science Purposes.

Cases in museums should be made to open at the back, so that specimens might be removed for purpose of scientific study, 3107, 3108.

Specimens mounted for the public are undesirable for students, 3108.

Assistant Professors.

Assistant professors, under chief professor (who should be entrusted with the teaching) are wanted at Oxford; the university would probably furnish funds for providing them, 3171, 3183, 3184.

See *Professors.*

Board of Trade.

The meteorological observations carried on at Kew are assisted by the Board of Trade, 3112.

Botany.

Oxford students of botany go into the physical science school only for honours, 3172, 3202.

British Association for the Advancement of Science.

Kew Observatory has been kept up for twenty years by the British Association and Royal Society; it will probably in future be maintained by Government, 3109–3111.

Aid given by British Association for observations on the rainfall of Britain, and for preparing a new map of the moon, 3113–3118.

To the proposed council of scientific advice, the British Association would probably make recommendations, 3126.

Bristol Museum.

The Bristol Museum is an exception to the generally unfavourable condition of provincial museums, 3103.

British Museum.

Desirable if the British Museum had power to send out to provincial museums, not merely its surplus, but well-arranged typical collections; it should have a travelling inspector, 3103.

A well-arranged collection in the British Museum is of the highest importance; it should be an index of the true state of natural history classification, 3104.

Numerous natural history specimens are sent from Oxford Museum to British Museum to be named, 3106.

Vast extent of the British Museum collections; a large proportion of specimens might be removed to drawers, 3107.

The British Museum should be considered as an exhibition for the public, having necessary books and arrangements for students, 3107.

In the British Museum, the cases should open at the back, so that students might take specimens out, 3107.

Specimens mounted for the public are undesirable for study, 3108.

Brodie, Sir Benjamin.

His allusion to the chemical teaching at Oxford being incomplete, 3174.

Buckland, Dr.

Ladies were accustomed to attend Dr. Buckland's lectures at Oxford University, 3178.

PHILLIPS, J., Esq.—cont.

Chairs.

General approval of endowment of chairs at Oxford for the higher instruction, 3171.

Chemistry.

No student who goes through the physical science school at Oxford, is unacquainted with chemistry, 3172, 3202.

Better chemical teaching required at Oxford; project for its increase, 3174.

Christ Church College (Oxford).

Large amount of physical science teaching at Christ Church College; scholarships, 3190, 3193.

Competition. See *Scholarships.*

Contributions for Science Purposes.

Large sums spent for the advancement of science by provincial institutions, 3163.

Council of Scientific Advice.

Appointment of such a council desirable; Government Grant Committee a good model, but five persons (instead of 41) would be sufficient to form it, 3113, 3123–3125.

The council might receive and consider recommendations from the Royal Society, British Association, &c., 3126.

A council formed of a large number of members divided into committees might answer; men of science would help, though want of time would render it difficult for them, 3127, 3128, 3141–3143, 3147, 3148.

The council should grant money for special research; not for physical laboratories, 3129–3131.

Persons eminent in science, and also persons responsible to the Legislature, should form the council, 3132–3136, 3149.

The establishment of such a council would not break up the present system of grants, &c., 3137.

The probable functions of the council would be, to promote observation of physical phenomena; scientific education would probably come before it, 3138–3141.

The members of such a council should be paid for their services, and also the inspectors of museums, &c., under them, 3144–3146.

The council of the Royal Society would be the best body for selecting members for the council of advice, 3150.

The council of advice should have authority over scientific notices, which are now published under so imperfect a system, 3205–3209.

Degrees.

Degrees can be obtained in the Oxford physical science school, but the examinations in geology, mineralogy, zoology, and botany are optional, 3203, 3204.

See *Examinations.*

Education.

A council of scientific advice would probably have to consider questions of the scientific education of the country, 3140.

Endowed Schools' Commission.

In view of the science teaching proposed by the Endowed Schools' Commission, more Oxford scholarships would be desirable, and they may be forthcoming when good scholars are produced, 3195–3199.

Endowment.

Endowment of chairs for the higher instruction at Oxford would be desirable generally, 3171.

Examinations.

No pupil unacquainted with physics, chemistry, or physiology passes the examination of the physical science school at Oxford; geology, mineralogy, and botany are subjects of examinations for honours, 3172.

Competitive examinations for scholarships in physical science at Oxford; six or eight persons competed at Magdalen, 3194.

No special examination in geology at Oxford; this does not apply to the proper physical science school, 3200, 3201.

In examinations for degrees at the Oxford physical science school, geology, mineralogy, zoology, and botany are optional subjects, 3203, 3204.

Examiners.

The members of a council of advice should be paid like Oxford University examiners, 3144.

Field Clubs.

Field clubs are numerous and active, and are spreading a good amount of natural history knowledge, 3205.

Geology.

Oxford students of geology go into the physical science school only for honours, 3172, 3202.

Undergraduates, ladies, heads of houses, &c., attend the geology class at Oxford, 3178.

There is no special examination in geology at Oxford, 3200.

Phillips, J., Esq.—cont.

Government.

In a council of scientific advice there should be members directly responsible to Government, 3132, 3149.

Government Grant Committee (Royal Society).

Limited action of Government Grant Committee; small amount of funds; many observers not assisted, 3114–3120.

More publicity should be given to the proceedings of the committee; reports of grants, &c. should be published, 3121, 3122, 3155, 3156.

The committee would be a good model for a board of scientific advice, but five persons (instead of 40) would suffice, 3123–3126, 3159, 3161.

The proposed council of scientific advice would probably continue the grant to the Government Grant Committee, 3157–3159.

Objection to Government Grant Committee being subdivided into sub-committees, 3151–3153.

The committee might make recommendations to Government to enlarge the grant for specific objects, 3154.

After preparation, the grant of the committee should be largely increased, and grow with the requirements of science, 3162–3165.

Government Grants in aid of Science.

Voluntary associations may promote interesting researches in science, but Government aid is required for permanent support; Kew Observatory instanced, 3109–3111.

Government aid should be given to the observations on rainfall in the British Islands, 3115.

There should be a minister, assisted by a board, to advise Government respecting grants for science purposes, 3123–3150.

Grants should be made, not for physical laboratories, but for definite research; purely educational establishments might have assistance, 3129–3131, 3166, 3167.

The publication and collection of scientific notices should be aided by grants of public money, 3205–3209.

Henslow, Professor.

Natural history specimens in Ipswich Museum excellently arranged by Professor Henslow, 3103.

Herschel, Sir John.

Allusion to valuable elementary books written by Sir John Herschel, 3147.

Honours.

Geology, mineralogy, and botany are subjects for honours only in the physical science school at Oxford, 3172, 3202.

Inspectors of Museums.

Desirable that a travelling inspector, in connexion with the British Museum, could visit officially the provincial museums, with a view to their proper classification, 3103, 3106.

Inspectors of museums might be professionally employed by a council of scientific advice, 3145.

Ipswich Museum.

Excellent arrangement, by Professor Henslow, of natural history specimens in Ipswich Museum, 3103.

Kew Observatory.

Observatory at Kew maintained for 20 years by British Association and Royal Society, will probably in future be maintained by Government, 3109, 3110.

Magnetic observations at Kew carried on by British Association, meteorological observations assisted by Board of Trade, 3111, 3112.

Laboratories (Physical).

Government grants should not be made for the mere purpose of establishing physical laboratories, but to aid scientific research, 3129–3131.

Laboratory at Magdalen College, &c., 3190.

Ladies.

The geology lectures at Oxford are attended by ladies, as was the custom at Dr. Buckland's lecture, 3178.

Lectures.

The lectures at Oxford are not lowered in tone by any peculiarity of the university system, 3172, 3173, 3178.

Liverpool Museum.

The Liverpool Museum is an exception to the usual bad arrangement of provincial museums, 3103.

Magdalen College (Oxford).

Considerable amount of physical science teaching at Magdalen College; laboratory; scholarships, 3190, 3193, 3194.

Phillips, J., Esq.—cont.

Magnetic Observations.

At Kew, magnetic observations are carried on at the expense of the British Association, 3111.

Merton College (Oxford).

Competitive science scholarships at Merton College, 3193.

Meteorological Observations.

The meteorological observations carried on at Kew are assisted by the Board of Trade, 3112.

Miller, Dr. (of Cumberland).

Observations on the rainfall of Britain made by Dr. Miller, 3115.

Mineralogy.

Oxford students of mineralogy go into the physical science school only for honours, 3172, 3202.

Minister for Science Purposes.

Appointment of a minister to recommend grants for science purposes desirable; he should be assisted by a board, 3123, 3124.

See *Council of Scientific Advice.*

Moon.

New map of the moon being prepared with assistance of British Association; telescope furnished by Government Grant Committee, 3116–3118.

Museums.

Condition of almost all provincial museums unfavourable regarding natural history collections; exceptions at Ipswich, York, Liverpool, and Bristol; desirable if British Museum could send out typical collections; also a travelling inspector, 3103, 3145.

Government inspection would be welcomed by managers of provincial museums, 3106.

All museums should be considered as exhibitions for the public, having necessary books and arrangements for students, 3107.

The mounted specimens in museums are mostly undesirable for purposes of study, 3108.

See *British Museum*, &c.

Natural History.

Defective arrangement of natural history collections in most provincial museums, 3103.

The British Museum should have the power of furnishing provincial museums with typical natural history specimens, 3103.

A travelling inspector, in connexion with the British Museum, would remedy the imperfect natural history classifications in provincial museums, 3103, 3106.

Importance of a well-arranged and indexed natural history collection at the British Museum, 3104.

Multitude of natural history specimens in British Museum; a large proportion might be kept in drawers, 3107.

In museums, natural history specimens should be available for removal from cases by students; specimens mounted for the public are mostly undesirable for study, 3107, 3108.

Much natural history knowledge is being spread by the numerous field-clubs, 3205.

Observatories.

Observatories for continuous research would be proper objects for public grants, 3129–3131, 3139, 3140, 3166.

See *Kew Observatory, Magnetic Observations*, &c.

Original Research.

The British Association is adapted to assist scientific research, but not to establish permanent experimental institutions, 3109.

Dr. Miller and Mr. Symons' observations on the rainfall of Britain, should have Government aid; aided (but not sufficiently) by Government Grant Committee, 3113–3116.

Observations on the moon, promoted by British Association; telescope granted by Government Grant Committee, 3116–3118.

Government grants should be applied to promotion of original research, 3129–3131.

Oxford professors should have opportunity for original research, 3171, 3183.

Oxford Museum. See *Oxford University.*

Oxford University.

Classification of objects in the Oxford Museum; reference frequently made to British Museum, 3106.

Members of a council of scientific advice should be paid like Oxford University examiners, 3144.

New buildings, apparatus, demonstrator, &c. at Oxford, for teaching experimental physics, 3168–3170.

Phillips, J., Esq.—*Oxford University*—cont.

University professors; they should have opportunity for research; should lecture only at will, and have assistant professors; university might contribute to augment teaching power; professors are represented in the council, 3171, 3183–3189.

University students; all who go through the physical science school are acquainted with physics, chemistry, or physiology; geology, mineralogy, and botany are taken only for honours; the best enter University well prepared, 3172, 3174, 3202.

University lectures are not lowered in tone by any peculiarity of the Oxford system, 3172, 3173.

Want of better chemical teaching at Oxford; projected increase of such teaching, 3174.

New body of students, called "non adscripti" lately established at Oxford; not connected with any college; number under a hundred, 3175–3179, 3182.

Undergraduates, ladies, heads of houses, &c. attend the geology lectures at Oxford, 3178.

In the university, there is no arrangement for special instruction, but facilities would be given in that respect, 3180, 3181.

Colleges at Oxford promote physical science, but doubtful whether they would contribute to University chest for payment of assistant professors, 3190.

The growth of science teaching in the colleges will not diminish the classes directed by the University professors, 3190.

The more private teaching, the better for the public teaching of Oxford University, 3191.

The present favourable tendency towards physical science at Oxford had better be allowed to grow by its natural strength, 3191, 3192.

Science scholarships in several colleges at Oxford; competition would be greater were they more generally known, 3194.

More Oxford scholarships desirable in view of the scientific instruction proposed by Endowed Schools' Commission; they may be forthcoming when the scholars are produced, 3195–3199.

No special examination in geology at Oxford; this does not apply to the proper physical science school, 3200, 3201.

Degrees can be obtained in the physical science school at Oxford; but examinations in geology, mineralogy, zoology, or botany are optional, 3203, 3204.

Physics.

New building, &c. at Oxford for teaching experimental physics, 3168–3170.

No student goes through the physical science school at Oxford unacquainted with experimental physics, 3172, 3202.

Physiology.

In the physical science school at Oxford no student passes who is unacquainted with physiology, 3172, 3202.

Professors.

Suggestion of a method for the appointment of professors, 3132.

Oxford professors should have opportunity for research; they should lecture only at will, and have assistant professors; University might furnish funds for this purpose, 3171, 3183, 3184.

At Oxford, professors are represented in the bodies which decide on finance; they are elected as professors and masters of arts, 3185–3189.

The classes of the University professors at Oxford would not be diminished by the growth of science teaching in the colleges, 3190.

Rainfall.

Valuable observations on the rainfall of Britain by Dr. Miller and Mr. Symons; Government aid should be given to these researches, 3113–3116.

Royal Irish Academy.

To proposed council of scientific advice, the Royal Irish Academy would probably make recommendations, 3126.

Royal Society.

Aid given to Kew Observatory by Royal Society, 3109.

To a council of scientific advice, the Royal Society would probably make recommendations, 3126, 3153 [illegible].

See Government Grant [illegible]

Royal Society of Edinburgh.

The society would probably make recommendations to proposed council of scientific advice, 3126.

Salaries.

In the proposed council of scientific advice, the members and those they employ should have salaries, 3144.

Phillips, J., Esq.—cont.

Scholarships.

At Oxford there are science scholarships open to competition in several colleges; competition would be greater were they more generally known, 3193, 3194.

To promote science in endowed schools, more Oxford scholarships would be desirable; when good scholars are produced, scholarships will probably be provided; masters would train for scholarships, 3195–3199.

Schools.

More Oxford competitive scholarships will be desirable to meet the increased science teaching in endowed schools, 3195–3199.

Science.

Provincial natural history collections; their imperfect classification; Government inspection desirable, 3103, 3106–3108, 3145.

British Museum; might furnish provincial museums with typical collections; it should form an index of the true state of natural history classification; its exhibited collections might be reduced, by putting specimens in drawers, 3103–3107.

Museums must be considered both as public exhibitions and as places of study, 3107, 3108.

Aid to science by British Association, Board of Trade, and Government Grant Committee, 3109–3122, 3125, 3151–3165.

Advantage to science from formation of a council of scientific advice, 3123–3150.

Some superior organisation for the advancement of science is requisite, 3128.

Definite scientific research should be aided by Government, not physical laboratories, 3129–3131.

Provincial institutions spend large sums for advancement of science, 3166.

Public money should not be given to voluntary institutions, except schools or colleges, 3166–3168.

Public feeling with respect to physical science is daily advancing, [illegible].

Diffusion of natural history science through numerous field clubs, 3205.

Great want of a proper method of publishing or collecting scientific notices; this might be aided by public money, [illegible].

See Oxford University.

Scientific Publications.

Great importance of some system of publishing scientific notices; the best should be collected; grants should be given for this purpose, 3205–3209.

Scientific Societies.

Great amount of voluntary assistance to scientific societies given by men of science, 3142.

Provincial institutions are unacquainted with the aid they might derive from the Government Grant Committee; they spend large sums in the advancement of science, 3155, 3166.

Students.

In museums, students should have opportunity of taking specimens out of cases for examination, 3107.

No student at Oxford goes through the physical science school unacquainted with physics, chemistry, or physiology; students of geology, mineralogy, and botany go only for honours, 3172.

The best students at Oxford enter prepared to take the highest instruction, 3174.

At Oxford there is a new body of "non adscripti" students, not connected with any college, not numerous, are under supervision, 3175–3179, 3182.

Undergraduates, ladies, heads of houses, &c. attend the geology lectures at Oxford, 3178.

Although at Oxford there is no special instruction for students, facilities would probably be given in that respect, 3180, 3181.

Science scholarships at Oxford; competition of students; [illegible]

Students can obtain degrees in the Oxford physical science school, but they are only optional examinations in geology, mineralogy, zoology, or botany, [illegible].

Symons, Mr. G. J.

Observations by Mr. Symons on the rainfall of Britain; he should have Government assistance [illegible] grants made to him by Royal Society, [illegible]

Text-books.

Valuable elementary text-books [illegible] school, 3147.

York Museum.

Excellence of [illegible] York Museum, [illegible]

ROLLESTON, GEORGE, Esq., M.D., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
Adequate accommodation at Oxford University for Linacre professor of physiology; it might be extended, 3215–3217, 3707, 3708.

Age of Science Students.
Boys in schools should, up to 16 years of age, have both literary and scientific education; after 16, those with special capabilities for science should pursue it, 3691, 3692.
Boys from 11 to 16 should be trained in botany, physics, chemistry, mathematics, and physical geography, 3719, 3735, 3736, 3740, 3741.
A boy who elects for natural science should take up German after 16 years, 3720–3722.

Aldrichian Professorship of Anatomy (Oxford).
Now comprised in the Linacre professorship of physiology, 3210–3213.

Anatomy.
The Aldrichian and Tomlinsonian professorships of anatomy at Oxford are now comprised in the Linacre professorship, 3210–3213.
The teaching of anatomy should be separate from physiology, 3238–3240.
Anatomy should be properly represented in Oxford Museum, 3709.

Appointment of Professors. See *Election of Professors.*

Assistant Professors.
Insufficient teaching power at Oxford; there should be one demonstrator to every eight students; the colleges should be looked to for "professores extraordinarii;" these should not be permanent officers, 3238, 3242*a*, 3262.

Biology.
Biology is the term employed now for physiology proper and morphology, 3211.
Professorships of biology should be multiplied, 3261.
See *Physiology.*

Botany.
Between 11 and 16 years, boys should have a training in botany, 3719.

British Association.
Allusion to British Association Report, as to success of science teaching at Rugby, without diminution of classics, 3697.

Chemistry.
Between 11 and 16 years, boys should have a training in chemistry, 3719.

Children.
Boys should have both literary and scientific training up to 16 years, when there should be a bifurcation in schools, and special scientific ability recognized, 3231, 3691–3695, 3715.
From 11 to 16 years, boys should be trained in botany, physics, chemistry, mathematics, and physical geography, 3719, 3735–3741.
Boys should not be compelled to learn Greek; those who elect for natural science should take up German after 16 years, 3720–3722.

Classics. See *Literature.*

Degrees.
Oxford should confer degrees for natural science; but degrees in science not essential; "B. Sc." not more valuable than "B. A.," 3255, 3256, 3701–3701.

Demonstrations.
Physiological demonstrations at Oxford; more valuable than lectures, 3222–3227.

Demonstrators. See *Assistant Professors.*

Education.
To 16 years of age, education should be both literary and scientific; after 16, those with special capabilities for science should devote themselves to it, 3231, 3691, 3692.
Objection to separate schools for literature and science; a great point in education to keep pupils together, 3695, 3699, 3701, 3715, 3718.
The education of boys, before 16 years, should comprise botany, chemistry, &c.; after 16, for science students, German should be compulsory, but not Greek, 3719–3722.
Approval of system of education in German realgymnasia, where science is superadded to the humanistic gymnasium, 3744.

ROLLESTON, Dr.—cont.

Election of Professors.
Importance of a good method of electing professors; should not all be appointed by same board; board should be not more than five, three being scientific men, who should guide the board, and be responsible; typical board suggested, 3240, 3248, 3264–3267.
All Oxford professors not now appointed by same board. Where three professors in one subject appointed, it might be done by the Crown, scientific board, and resident masters of art, 3249.

Endowed Schools. See *Schools.*

Endowed Schools' Commission.
Objection to system of education proposed by Commission, that literature and science schools should be separate, 3694, 3695.

Ethnology.
Ethnology should be properly represented in Oxford Museum, 3709, 3713.

Ewart, Mr.
Dispensing with residence in colleges (as proposed in Mr. Ewart's bill) would increase number of students in universities, 3254.

Examinations.
Oxford students of physiology recommended not to begin until they can pass their responsions and moderations, 3220, 3221.
Responsions and moderations' examinations have to be passed at fixed times; advantage of removal of this restriction, 3254.
A matriculation examination at Oxford University would act most favourably on schools, 3699, 3700, 3732.

Fees.
The colleges at Oxford have sometimes returned to students of science a part of their tuitional money, to enable them to pay their fees at the museum, 3230.

Fellowships.
At Merton College, Oxford, four fellowships are set aside to support the Linacre professorship of physiology, 3213.
If a person with honours in one subject were allowed to compete for other honours, and got a fellowship, his example would be advantageous, 3232.
A developement of the scientific fellowships, &c. at Oxford University would react favourably on schools, 3699, 3700.

German.
Those who elect for natural science should take up German after 16 years of age, 3722.

Germany.
Subjection of professors in Germany to public opinion, good results therefrom, 3250.
German gymnasia, realschulen, and realgymnasia; approval of the system of the latter, which superadds science to the humanistic gymnasium, 3742–3745.

Greek.
All boys should not be compelled to learn Greek; nor need it be imposed on persons going to the universities, 3720, 3721, 3727–3730.

Greenwood and Roscoe, Professors.
Report on German schools by Professors Greenwood and Roscoe; they were in favour of requiring literary culture from all, 3718, 3742–3746.

Honours.
Advantage if Oxford University men, having honours, were allowed to compete for any other honours; at present no honour in any school is obtainable after 18 terms, 3232, 3233, 3254, 3734.

Latin.
All boys should be taught Latin before the age of 16 years, 3721.

Lectures.
Lectures of Linacre professor at Oxford are not prescribed in number; demonstrations given, which are more valuable than lectures, 3222–3227.
Professors should not be compelled to give a particular number of lectures; those relieved from personal teaching might issue printed lectures, worthy of the university, 3242–3247.

Linacre Professorship of Physiology (Oxford).
Comprises the Aldrichian and Tomlinsonian professorships of anatomy, 3211.
Founded in 1857, at Merton College, by the Oxford University Commission; four fellowships set aside for its support, 3212, 3213.
A demonstrator appointed in 1863, 3213.
Emoluments of professor and demonstrator, 3214.

Rolleston, Dr.—*Linacre Professorship of Physiology (Oxford)*—cont.
- Ample accommodation for this professorship in the museum, 3215–3217.
- Students; 37 the average number; certain amount of previous study practically prescribed; students submit their note-books, &c. to the professor; many enter the course ill-prepared; preliminary scientific instruction wanted at schools, 3218–3221, 3227–3231.
- Professor resides in university six months in the year 3222.
- Lectures; number not prescribed; demonstrations given, which are more valuable than lectures, 3222–3227.

Literature.
- The two lines of literature and science cannot be well worked simultaneously by a science student; previous study essential, 3220.
- Literary culture at schools should not be reduced; science should also be taught, 3231, 3691–3695.
- Objection to classical schools being distinct from scientific schools, except in special cases, 3694–3699, 3701, 3718, 3746–3749.
- Success of scientific teaching at Rugby School, without diminution of classical studies, 3697.
- A man who takes literature now, without science, is at a disadvantage, 3731.
- Approval of system of German realgymnasia, which superadd science to the humanistic gymnasium, 3742–3745.

Lyttelton, Lord.
- Objection to his system of separating classical from scientific schools, 3694, 3695, 3701.

Mathematics.
- Boys should be early introduced to the study of mathematics, 3735.

Matriculation.
- Desirability of having a matriculation examination at Oxford University, 3699, 3700, 3732.

Medicine.
- About one fourth of the students under Linacre professor of physiology at Oxford have gone into the medical profession, 3235, 3236.

Merton College (Oxford).
- Four fellowships of Merton College go to support the Linacre professorship of physiology, 3212–3214.

Museums.
- The Museum at Oxford should be of use to both pupils and scientific men; it should embrace ethnology, 3709–3714, 3238.
- A museum, to answer its proper end, should have an element of originality, 3711.

Original Research.
- Antagonism between teaching and original research, 3240, 3241.
- Advantage of long vacation to pursuit of original research, 3241.
- To get real good from the field of science, a person must himself have worked one plot, 3241.
- Instances of Linacre professor's students who have engaged in original research, 3260.
- The practical school of physiology at Oxford might be used as a place for original research, 3261.

Oxford University.
- Linacre professorship of physiology at Merton College; founded in 1857; demonstrator appointed; emoluments; ample accommodation for professor; examination, students, lectures, &c., 3211–3231, 3235, 3236, 3257–3260, 3707, 3708.
- Science taught in the colleges at Oxford; many students begin science instruction in them, and afterwards go to the museum, 3230.
- The University does not allot a sufficient number of awards for natural science, but it is not reluctant to do so; persons having honours in one subject should be allowed to compete for other honours; it would cause emulation in students, 3232, 3233, 3733.
- Advantage of the natural science teaching to Oxford students in after life, 3234.
- Insufficiency of teachers in the University; necessity of having a demonstrator for every eight persons per diem, 3238, 3242*a*.
- Teaching of human anatomy at the University; anatomy should be taught separately from physiology, 3238, 3239.
- Colleges at Oxford might well devote funds to reward special lines of activity, 3247.

Rolleston, Dr.—*Oxford University*—cont.
- Oxford professors; appointment; type of a board of election; professors are not now all appointed by same board; professors teaching similar subjects should be allowed to settle what parts they would take, 3210, 3248–3253, 3261–3267.
- Removal of restriction that a man has to pass two examinations (responsions and moderations) at certain fixed times, together with affiliation of colleges in other towns, would increase number of students at Oxford, 3254.
- Oxford University should confer degrees for natural science; but degrees in science not essential; "B. Sc." not more valuable than "B.A.," 3255, 3256, 3701–3704.
- The practical school of physiology at Oxford might be used as a place for original research, 3261.
- The professor of physiology at Oxford should be definitely a University professor; for "professores extraordinarii" the colleges should be looked to, 3262.
- A development of the scientific teaching, fellowships, and scholarships, and also a matriculation examination, at Oxford, would react most favourably on schools, 3699, 3700.
- Museum at Oxford should be of use to both pupils and scientific men; it should have an element of originality; should embrace ethnology, &c., 3709–3714.

Oxford University Commission.
- The Commission founded the Linacre professorship of physiology in 1857, 3212.

Pettenkofer, Professor.
- Allusion to his comparison of the relative value of the German gymnasia, realschulen, and realgymnasia, 3743, 3744.

Physical Geography.
- Boys should be early introduced to the study of physical geography, 3736.

Physics.
- Between 11 and 16 years, boys should have a training in physics, 3719.

Physiology.
- The term comprehends physiology proper and morphology, and is equivalent to biology, 3211.
- Linacre professorship of physiology at Oxford; students; lectures, &c.; one fourth of the students have gone into the medical profession, 3211–3231, 3235, 3236, 3257–3260, 3707, 3708.
- In teaching physiology, one demonstrator for eight students per diem is essential, 3238.
- Anatomy should be taught separately from physiology; teaching of human anatomy at Oxford, 3238–3240.
- The practical school of physiology at Oxford might be used for original research, 3261.

Practical Instruction.
- Physiological demonstrations at Oxford; great value of the instruction, 3227.

Professores Extraordinarii. See *Assistant Professors.*

Professors.
- Linacre professor of physiology at Oxford; his students, lectures, &c., 3211–3231, 3235, 3236, 3257–3260, 3707, 3708.
- Oxford professors; appointment; board of election suggested, composed of five persons, three being men of science, and professors are not all appointed by same board now, 3210, 3248–3253, 3261–3267.
- Importance of a natural science professor working at original research, 3241, 3244.
- A professor might be relieved from personal teaching, but then he should issue printed lectures worthy of the University; some professors can speak better in print, 3242, 3243, 3246.
- The securing of an eminent man in a seat of learning is of the highest importance, 3245.
- A professor should be subjected to the agency of healthy public opinion, 3249, 3250.
- Professors teaching similar subjects should be allowed to settle between them what parts to take, 3252, 3253.
- The professor of a large subject that pays badly at Oxford, should be a University professor; for "professores extraordinarii" the colleges should be looked to; the former only should be permanent, 3262.

Professorships.
- Linacre professorship of physiology at Oxford, comprising the Aldrichian and Tomlinsonian professorships of anatomy, 3211–3231, 3235, 3236, 3257–3260, 3707, 3708.

ROLLESTON, Dr.—*Professorships*—cont.
Election to professorships; necessity of a good method of election; type of a board of appointment suggested; members of the board should be experts, and responsible, 3240, 3248, 3249, 3264–3267.
Professorships of biology should be multiplied, 3261.

Realgymnasia (Germany).
Approval of realgymnasia, which in system superadd science to the humanistic gymnasium, 3742–3745.

Rugby School.
Successful teaching of science at Rugby, without diminution of classics, 3697.

Salaries.
The salary of the Linacre professor at Oxford is 1,000*l.*, 200*l.* of it being paid to the demonstrator, 3214.

Scholarships.
A development of the scientific scholarships, &c. at Oxford University would react favourably on schools 3699, 3700, 3731, 3732.

Schools.
At schools, as well as at universities, the value of science should be recognized; science has been put aside in schools, 3231, 3746.
Literary and scientific culture should go together in schools for boys up to 16 years, when there should be a bifurcation, and those specially qualified for science be allowed to pursue it, 3231, 3691–3693, 3715, 3740, 3741.
Objection to principle of literary schools being distinct from scientific schools, 3694, 3695, 3701, 3718.
Head masters of schools may depreciate particular studies, but those with adequate knowledge of literature and science might carry on both subjects, 3695–3699.
Successful scientific teaching at Rugby School, without diminution of classical studies, 3697.
Development of scientific teaching, fellowships, and scholarships, and also a matriculation examination, at Oxford University, would react favourably on schools, 3699, 3700.
Science teaching in schools is becoming a profession, 3705, 3706.
In schools, botany, physics, chemistry, mathematics, and physical geography should be taught to boys of 11 to 16 years; Greek should not be compulsory, but German should be, after 16, for science pupils, 3719–3722, 3735, 3736.
Bifurcation in schools need not necessarily involve a large staff of masters, 3723–3725.
For a manufacturing district, Greek might be omitted from school instruction, 3726–3730.
German schools; approval of system of realgymnasia, which superadd science to the humanistic gymnasium, 3742–3745.
Special schools of science desirable in localities where they are in demand, 3746–3749.

Science.
Physiology (as understood at Oxford) is equivalent to biology in its widest modern sense, 3211.
Linacre professorship of physiology at Oxford, 3211–3231.
A science student cannot advantageously work literature also, 3220.
Great value of demonstrations in science teaching, 3227.
Importance of science teaching both in schools and universities, 3231.
In schools, science and literature should be taught together; boys with scientific predilections should be separated at 16 years; science has been put aside in schools, 3231, 3691–3699, 3716–3718.
Value of Oxford plan of studying natural science, as preparation for a future career, 3234.
Antagonism between teaching and original research, 3240, 3241.
Advantage of a professorship to pursuit of scientific research, 3241.
To get a good knowledge of a field of science, a person must have tilled one small plot himself, 3241.
Advantage to science students of the plan of affiliation of colleges, 3251.
Professors of biology should be multiplied, 3261.
Natural science has a great effect upon all thought; a young man who simply takes literature now is at a disadvantage, 3731.

Science Schools.
Objection to science schools and literary schools being distinct, except in localities where science schools are in demand, 3694–3699, 3701, 3718, 3746–3749.

ROLLESTON, Dr.—cont.
Science Teachers.
Science teaching has become a profession; many Oxford students have become teachers of natural science; demand for teachers in schools, 3257–3260, 3705, 3706.
See *Professors.*

Students.
Students under Linacre professor of physiology at Oxford; many enter ill prepared; accommodation might be had for more students, 3218–3221, 3227–3231, 3707, 3708.
Oxford University does not offer students a sufficient number of rewards for science, but it is not reluctant to do so, 3332.
Advantage of natural science teaching at Oxford to students in after life; students under Linacre professor of physiology have become doctors, teachers of science, &c.; some have written papers, 3235, 3236, 3257–3260, 3705, 3706, 3733.
Affiliation of colleges in other towns would increase number of students at Oxford, 3251.
Oxford should confer on students degrees for natural science; but degrees in science not essential; "B. Sc." not more valuable than "B. A.," 3255, 3256.

Tomlinsonian Professorship of Anatomy (Oxford).
Now comprised in Linacre professorship of physiology, 3210–3213.

Universities.
Greek should not be a *sine quâ non* for persons becoming members of universities, 3726–3730.

Wilson, Mr.
Successful teaching of science at Rugby School by Mr. Wilson without diminution of classical studies, 3697.

PRICE, Rev. BARTHOLOMEW, M.A. (Index of his Evidence.)

Age of Students.
Students at Oxford matriculate earlier than formerly, many coming up at 17 years; the age of young men coming from large public schools is increased, they being kept at school until 19 years, 3426.
Many Oxford students preparing for the professions would be ready to leave at 19 years of age, after having taken their degrees, 3426.

Aldrichian Professorship (Oxford).
This is now changed into the office of a demonstrator, 3385, 3386.

Applied Mechanics. See *Mechanics.*

Apparatus for Science Purposes.
Contributions of Oxford University for apparatus; if more be required, it must come from students or from the colleges, 3280–3283, 3304–3308.
Grant for apparatus for Hyde Institution physical laboratory made by University, 3282.

Assistant Professors.
Demonstrators connected with professorships at Oxford University, 3283, 3345.
Desirable to have one professor at the head of his department, with demonstrators under him, 3344–3346.
The Aldrichian professorship at Oxford is now changed into the office of a demonstrator, 3385, 3386.

Biology.
Biology should be included in Oxford University curriculum, 3272.
See *Physiology.*

Bodleian Library (Oxford).
The library contains a large number of scientific books, which it lends to the museum; cost of library to University, 3284, 3288, 3302, 3303.

Botany.
There is no professor of botany connected with Oxford Museum; desirable there should be, 3411, 3412.

Chairs. See *Professorships.*

Chemistry.
Chemistry should be included in Oxford University curriculum, 3272.
Cost of chemical department at Oxford Museum, 3280–3283.
Waynflete professorship of chemistry established in Magdalen College, Oxford, 3383.

Christ Church College (Oxford).
Dr. Lee's fund at Christ Church is partly applied to scientific purposes; the Lee readerships are Christ Church professorships, 3289, 3388.

PRICE, Rev. B.—cont.

Clarendon Press (Oxford).

The income from the Clarendon Press has been disbursed for University purposes, 3291–3295.

Colleges in Universities. See *Oxford University, &c.*

Contributions for Science Purposes.

Contributions of Oxford University for promotion of science amount to about one tenth of whole income, 3280–3283, 3301–3303.

Dr. Lee's fund at Christ Church is partly applied to science, 3289.

Contributions of colleges at Oxford for University purposes, 3311.

Convocation. See *Oxford University.*

Cost, Income, and Expenditure.

Cost for building, maintenance, officers, apparatus, &c., of Oxford Museum, 3280–3283.

Income and expenditure of Oxford University; income from benefactions, the press, &c., 3290–3303.

The University income from fees, &c. could not be increased; the expenditure of the University increases every year, 3298–3300.

One tenth of the University income is expended for science purposes, 3301–3303.

The income from college endowments at Oxford is increasing, 3309–3312.

Sums expended by Oxford University on the park, Bodleian Library, art galleries, &c., 3403*a*–3407.

Low cost of living of unattached students at Oxford, 3448, 3449.

Degrees.

Fees for degrees paid at Oxford University, 3295.

Desirability of there being distinct degrees for science, including mathematics; the holders should be members of Convocation, 3358–3370.

A new degree, such as Master of Science or Bachelor of Science, desirable, 3359.

Degrees in arts might be almost confined to non-professional men, 3361, 3362.

Rights of Convocation at Oxford are limited to those who take degrees in arts; Bachelors of Science or Bachelors of Law should be members of Convocation, 3365, 3366.

The Oxford B.A. degree can be obtained without knowledge of mechanics; examinations might remedy this; the difficulty is, that teachers of students are mostly unacquainted with the subject, 3377–3380.

Taking of degrees by Oxford students preparing for professions would be facilitated if literary examination were less advanced, 3427.

At Oxford, a degree can be obtained with only a very little mathematics, 3457.

Demonstrators. See *Assistant Professors.*

Education.

A general and purely scientific (not technical) education should be given at Oxford University, 3269.

Natural science students should study Latin, but not necessarily Greek, 3274.

People in the most populous districts, and in the north of England especially, do not care for Greek and Latin, 3414.

Endowed schools should teach physical science, 3418.

See *Oxford University.*

Endowments.

Savilian, Sedleian, and other endowments at Oxford University, 3283.

The income from college endowments at Oxford is increasing, 3309–3312.

Waynflete endowments for professorships established in Magdalen College, Oxford, 3383, 3384.

Engineering.

In its general principles, engineering is not technical; it should be taught at Oxford; students should go to workshops for details, 3373, 3422, 3425.

A professor of applied mechanics and engineering is wanted at Oxford, 3329, 3391.

See *Mechanics.*

Examinations.

An examination-test in literature desirable for Oxford University students; a scientific test not now practicable, 3275–3278, 3400.

Objection to matriculation examination at Oxford; it would exclude persons who might benefit by the instruction, 3275, 3276, 3430–3432, 3439–3448.

For physical science scholarships at Oxford, colleges provide examinations, or call in professors; approval of latter course, examinations being connected with museum, 3351–3357.

PRICE, Rev. B. *Examinations*—cont.

Examinations at Oxford for degrees; those for physical science should include mathematics, 3363–3370.

For B.A. degrees at Oxford, examinations might be modified, to prevent those passing who have no knowledge of mechanics, 3377–3380.

A less advanced literary examination would facilitate taking of degrees by Oxford students preparing for professions, 3427.

Exhibitions. See *Scholarships and Exhibitions.*

Faculties.

There should be a distinct faculty of physical science, as of old there were faculties of divinity, medicine, and law, 3358–3360.

Fees.

Fees for matriculation, degrees, &c. at Oxford University; they could not well be increased, 3295–3299, 3342.

Professors at Oxford receive small capitation fees, 3336, 3337, 3343.

Fellowships.

Fellowship examinations at the colleges at Oxford are mostly conducted by professors, 3351.

Retiring allowances for professors might be provided by connecting fellowships with chairs, 3392.

Grants for Science Purposes. See *Cost, &c.*

Greek.

Natural science students need not study Greek, 3274.

People in the most populous districts, and in the north of England especially, do not care for Greek, 3414.

Honours.

The highest classical honours at Oxford may be obtained by one entirely ignorant of science, 3403.

See *Degrees.*

Income and Expenditure. See *Cost, &c.*

Hyde Institution (Oxford).

A physical laboratory, erected under Lord Hyde's will, 3282, 3322–3326.

Laboratories (Physical).

Physical laboratories at Oxford, erected from fund created under Lord Hyde's will; grant of apparatus to the same by university, 3282, 3322–3326.

Latin.

Students of natural science should study Latin, 3274.

People in the most populous districts, and in the north of England especially, do not care for Latin, 3414.

Lee, Dr.

At Christ Church, Oxford, Dr. Lee's fund is partly applied to scientific purposes; the Lee readerships are Christ Church professorships, 3289, 3388.

Literature.

A foundation of literature essential before study of science; Greek might be given up, but not Latin, 3274, 3275, 3397.

An examination-test in literature desirable for Oxford students; a scientific test not practicable, 3275–3278, 3400.

Majority of Oxford scholarships are given for classics, which scholarships are usually more valuable than others, 3314–3321.

At Oxford, science is less valued (so far as prizes go) than classics or mathematics, but it is free to become as much valued, 3371, 3372.

Persons devoting themselves to literary pursuits would benefit by scientific training, 3399.

The highest classical honours at Oxford may be obtained by one entirely ignorant of science, 3403.

A less advanced literary examination would facilitate taking of degrees by Oxford students preparing for professions, 3427.

Magdalen College (Oxford).

Contributions of Magdalen College for science purposes, 3283.

Waynflete professorships founded by Magdalen College, for moral and metaphysical philosophy and chemistry; there are to be two others, for mineralogy and physical geography, 3381–3384, 3411.

Mathematics.

Mathematics should be included in Oxford University curriculum, 3273.

Only a few Oxford scholarships are given for mathematics, which scholarships are mostly less valuable than those given for classics, 3314, 3319–3321.

Degrees in physical science should include mathematics, 3363, 3364.

So far as prizes go, science is less valued than classics or mathematics at Oxford, 3371, 3372.

A degree can be obtained at Oxford almost without any mathematics, 3457.

Price, Rev. B.—cont.

Matriculation.
- Fees paid at Oxford University for matriculation by noblemen, bible clerks, &c., 3295, 3296.
- Objection to matriculation examination at Oxford University; dispensing with matriculation would not act injuriously on secondary schools, 3275, 3276, 3430–3432, 3438, [illegible].
- Students now matriculate earlier than formerly, many coming up to Oxford University at 17 years of age, 3426.
- There were 6[illegible] matriculations at Oxford for the year 1869, 3461.

Mechanics.
- A professor of applied mechanics and engineering is wanted at Oxford University; Professor Clifton's department should be divided, 3329, 3371, 3391.
- The principles of mechanics should be taught at Oxford, and the details learned in workshops; theoretical mechanics and mechanism should be taught together, 3373–3376.
- The B.A. degree at Oxford may be obtained without any knowledge of mechanics; this might be remedied in examination; but the difficulty is, that the students' teachers are mostly unacquainted with the subject, 3377–3380.
- Students attending mechanics' course at Oxford would probably be studying for teachers, or taking mechanics in the general course of study, 3422–3429.

Merton College (Oxford).
- Contributions of Merton College for science purposes, 3283.

Mineralogy.
- When funds become available, there is to be a Waynflete professorship of mineralogy at Magdalen College, Oxford, 3385.

Natural Philosophy. See *Physics, &c.*

New College (Oxford).
- Contributions of New College for science purposes, 3283.

Oxford University.
- The University should give purely scientific, as distinguished from technical, instruction, 3269.
- Physics, chemistry, and biology, with mathematics, should be embraced in the Oxford curriculum; also literary training, 3271–3274.
- Oxford students; they should be tested in literature on entering; many science students become teachers; number not large, but increasing; unattached students, 3275–3278, 3351–3357, 3391–3396, 3413–3421, 3448, 3449.
- Examinations at Oxford; matriculation examination undesirable, as it would exclude many who could profit by the instruction; examinations for college scholarships should be conducted by the professors, 3275–3276, 3351–3357, 3430–3448.
- Appliances for scientific demonstration at Oxford; museum, its cost of building and maintenance, apparatus, &c.; Radcliffe and Bodleian Libraries; Dr. Lee's fund at Christ Church, 3279–3289, 3302–3305.
- Physical laboratories at Oxford, erected under Lord Hyde's will; grant of apparatus to the same by University, 3282, 3322–3326.
- Yearly income and expenditure of University; one-tenth of [illegible] scientific education, 3290–3303, [illegible].
- Bequests to University by kings, bishops, &c., 3291.
- Colleges [illegible] Oxford; their incomes from endowments, [illegible] contributions for University [illegible] for science, examinations, [illegible].
- Scholarships at Oxford, about four-fifths for classics, [illegible] available [illegible] little competition for science scholarships, 3314, [illegible], 3319, 3357, 3371, 3372, 3415–3421.
- Oxford [illegible]; [illegible] attended [illegible] and small fees; [illegible] should have one professor, with demonstrators, [illegible] wanted, [illegible] conduct [illegible] examinations, 3337, 3345, 3351–3357, [illegible], 3460.
- The [illegible] instruction at Oxford; [illegible] professor [illegible] mechanics and [illegible] should be taught together [illegible] students, 3370, [illegible], 3376, 3422–3429.
- Professorships at Oxford, all endowed, some inadequately; [illegible] one wanted for applied mechanics, 3330–3335, 3381–3391.
- Demonstrators at Oxford; better to increase their number, than to have more than one professor at the head of a department, 3341–3346.

Price, Rev. B.—*Oxford University*—cont.
- Degrees at Oxford; faculty for physical science, including mathematics, wanted; the highest honours can be obtained now without science and with little mathematics, 3358–3380, 3403, 3454–3457.
- The teaching of science in endowed schools would be reciprocated by Oxford University, 3413–3421.
- The University may be looked to for scientific teachers, to be dispersed about the country, 3442–3446.
- Opening of University to students not belonging to a college; low cost of living under this system, 3448, 3449.
- The greatest possible freedom to studies should be given by the University, 3450–3453.
- The number of matriculations at Oxford for 1869 was 581, 3461.

Parliament.
- Colleges at Oxford must have sanction of Parliament to apply their funds to promotion of physical science, 3417, 3419.

Pensions. See *Superannuation.*

Physical Geography.
- At Magdalen College, Oxford, a professorship of physical geography is proposed, 3383, 3411.

Physics.
- Physics should be included in Oxford University curriculum, 3272.
- Cost of physical department at Oxford Museum, 3280–3283.
- Physical laboratories at Oxford, erected under Lord Hyde's will, 3282, 3322–3326.
- Little competition for physical science scholarships at Oxford; number of candidates might increase with more scholarships, 3317, 3318.

Physiology.
- Cost of physiological department at Oxford Museum, 3280–3283.

Professors.
- Oxford professors; their emoluments, which should be increased; provision made by the colleges for them and their demonstrators, &c., 3283, 3292, 3302, 3314, 3330–3335.
- A professor of applied mechanics and engineering is wanted at Oxford, 3329, 3391.
- The professors at Oxford partly bear expense of experimental courses, 3358.
- There is one professor only in each branch of science at Oxford; more undesirable; their assistants should be increased, 3341–3346, 3408, 3409.
- Professors should have retiring allowances, 3347, 3348, 3392, 3393, 3460.
- Approval of examinations for science scholarships in colleges at Oxford being conducted by professors, in connexion with museum, 3351–3357.
- No professor of botany connected with Oxford Museum; desirable there should be, 3411, 3412.

Professorships.
- Professorship of applied mechanics and engineering wanted at Oxford, 3329.
- Oxford professorships are all endowed; some inadequately, 3330–3335.
- Three departments at Oxford have demonstrators connected with professorships, [illegible].
- Waynflete, Savilian, Sedleian, and other professorships at Oxford connected with the University; 10 altogether, 3381–3391, 3411.
- The [illegible] readerships at Oxford are Christ Church professorships, [illegible].
- Some emoluments should be attached to professorships; this might be effected by connecting fellowships with chairs, [illegible].

Queen's College (Oxford).
- Contributions of Queen's College for science purposes, 3283.

Radcliffe Library (Oxford).
- Maintained by Radcliffe trustees; it is a scientific library, and essential to the museum, 3284–3288.

Readerships. See *Professorships.*

Salaries.
- Salaries of professors at Oxford; should be increased, 3283, 3292, 3302, 3314, 3335.

Scholarships and Exhibitions.
- Nearly 400 scholarships in Oxford University; for science, perhaps five are given annually, 15 or 20 for mathematics, and majority for classics; worth about 28,000*l.* a year, 3314–3316.
- Little competition for physical science scholarships at Oxford; more scholarships would increase competition, 3317, 3318, 3417, 3420.

PRICE, Rev. B.—*Scholarships and Examinations*—cont.
- Classical scholarships at Oxford are mostly more valuable than scientific or mathematical, 3319.
- Scholarships in natural science have only recently been given at Oxford; in mathematics, earlier, 3320, 3321.
- Desirability of offering science scholarships, with option of residence in or out of college, 3448, 3449.
- All colleges should provide a fund for scholarships in physical science, 3349, 3350.
- For physical science scholarships, colleges at Oxford provide examinations, or call in assistance of professors; approval of latter course, examination being connected with museum, 3351–3357.
- A fair proportion of Oxford scholarships, now given for other subjects, might be awarded to science, 3420, 3421.

Schools.
- Many Oxford science students become teachers in schools; great demand for them, 3394, 3395.
- Teaching of endowed schools should be directed to science; Oxford University would be in accordance with it, 3416–3418.
- The age of students entering Oxford University from public schools has increased; large schools keep boys till 19 years of age, 3426.
- When schools are improved, difficulty will be to get teachers; teachers may be expected from Oxford University, 3442–3446.
- Dispensing with matriculation examination at Oxford would not act injuriously on public schools, 3448.

Science.
- A purely scientific (not technical) education should be added to that which has been given at Oxford University, 3269–3272.
- There should be a distinct faculty for physical science, 3358–3370.
- At Oxford, science is not valued (so far as prizes go) so much as classics and mathematics, but it is free to become as valued, 3371, 3372.
- The elements of science should be known by all, 3398.
- The highest classical honours at Oxford may be taken by one entirely ignorant of science, 3403.
- The teaching of endowed schools should be directed to physical science, 3418.

Science Teachers.
- Many Oxford students become teachers of science and mathematics in schools; the number will probably largely increase, 3394–3396.
- When schools are improved, the difficulty will be to get teachers, 3442–3444.
- Oxford University scientific department may be looked to for teachers, to be diffused over the country, 3445, 3446.

Students.
- Want of literary education in science students; they should study Latin; might give up Greek, 3274, 3275.
- Examinations of Oxford students; literary test on entering desirable; objection to matriculation examination; a less-advanced literary examination desirable in the case of degrees taken by students preparing for professions, 3275–3278, 3357, 3427, 3430–3432, 3439–3448.
- Fees paid by Oxford students; undesirable to increase them, 3295–3299.
- Scholarships for scientific students at Oxford; more might be given; scholarships for unattached students desirable, 3313–3321, 3417, 3448.
- Oxford students might be taught the principles of engineering, and go to workshops for details, 3373.
- Oxford degrees; B.A. degree may be taken without knowing mechanics; students' teachers are unacquainted with the subject, 3377–3381, 3427.
- Many science students at Oxford become teachers in schools; great demand for them, 3394–3396.
- Oxford University, having promoted study of science, is not to be blamed for non-attendance of students, 3415.
- Students in mechanics' course at Oxford would either study for teachers, or take mechanics in their general studies; they would never be numerous, 3422–3429.
- Oxford students now have a tendency to matriculate earlier; the age of pupils coming from large schools is increased, 3426.
- Low cost of living of unattached students at Oxford, 3448, 3449.

Superannuation.
- Professors should have retiring allowances; this might be effected by connecting fellowships with chairs, 3347, 3348, 3392, 3393.
- There is no provision for pensions at Oxford, 3460.

PRICE, Rev. B.—cont.

Teachers. See *Science Teachers.*

Technical Instruction.
- Oxford University should not give technical instruction, 3269.
- Engineering, in its general principles, is not technical, 3373.

Wadham College (Oxford).
- Contributions of Wadham College for science purposes, 3283.

Waynflete Professorships (Oxford).
- Established and supported by Magdalen College; two are already founded, viz. for moral and metaphysical philosophy and chemistry; there are to be two more, for mineralogy and physical geography, 3381–3384.

Workshops.
- Oxford students might be taught the principles of engineering, and then go to industrial workshops for details, 3373, 3425.

Zoology.
- Cost of zoological department at Oxford Museum, 3280–3283.

SMITH, HENRY JOHN STEPHEN, Esq., M.A. (Index of his Evidence.)

Accommodation for Science Purposes.
- Further accommodation is wanted at Oxford University for teaching astronomy, 3477, 3478.

Apparatus for Science Purposes.
- Appliances for teaching astronomy are wanted at Oxford University, 3477, 3478.
- Desirability of Government forming a collection of scientific apparatus, and rendering it available for special research, 3543–3545.
- A provision of apparatus at Oxford is essential to prosecution of original research, 3556.

Assistant Professors.
- Demonstrators essential where practical instruction is to be given, 3489.
- Doubts as to head professors and sub-professors working together satisfactorily; independent lectureships, to be connected with fellowships, more desirable, 3489–3491.
- In the colleges at Oxford are to be found the best class of "repétiteurs," 3498.
- Colleges at Oxford should be compelled to appropriate fellowships to lectureships and demonstratorships; Christ Church the only college where this is done, 3546, 3547.
- Original research at Oxford would be promoted by the professors being aided by demonstrators, &c., 3554–3557.
  - See *Lecturers.*

Astronomy.
- Savilian professors of astronomy at Oxford have always been desirous of giving practical instruction; study of astronomy has languished of late; appliances for teaching wanted, 3477, 3478.

Biology.
- At Oxford, the subject of biology might be divided into morphology and physiology, 3560.

Botany.
- The study of botany is too much neglected at Oxford University, 3561.
- A student can pass out in the natural science school at Oxford with but little knowledge of botany, 3562.

Chemistry.
- Additional professors of chemistry are wanted at Oxford, 3487.

Christ Church College (Oxford).
- The Christ Church Lee's readerships are the only instances of Oxford fellowships being devoted to lectureships, 3546.

Colleges. See *Oxford University.*

Degrees.
- About 20 students at Oxford go out annually in mathematical honours, 3466–3468.
- For promotion of original research at Oxford, the university laboratories should be available to those who have taken their degrees and obtained fellowships, 3530, 3531.
- Degrees in science at Oxford not very desirable; if the B.Sc. degree did not imply a higher standard than the B.A. it would not be much estimated, 3534, 3535.
- A student can pass out in the natural science school at Oxford with but little knowledge of botany, 3562.

SMITH, H. J. S., Esq.—cont.

Education.
- Approval of the present college system of education at Oxford, 3496–3500.

Election of Professors.
- At Oxford, professors are appointed in various manners; system unsatisfactory, 3513, 3514.
- Electors to Savilian professorship; science not represented on the board, 3515, 3516.
- A board of election should represent the local scientific, the outside scientific, and the business elements; professors should be on the board, but in a minority; different boards desirable for different professorships, 3517, 3518.
- Danger of ecclesiastical element preponderating in boards of election at Oxford, 3519.
- A board similar to that proposed for the election of professors would form a suitable central authority for Oxford University, 3548, 3549.

Endowments.
- Oxford professors should be, and are, paid by endowment, 3501.
- If Oxford had the power of increasing professors' endowments, more funds would not probably be applied to natural science, 3502.
- Colleges at Oxford and endowments of professors, 3503–3505.
- An adequate endowment for a professor would be between 600*l*. and 1,000*l*.; or 600*l*. and a fellowship, 3512.
- Uncertainty of endowment at Oxford being augmented is a bar to first-rate men seeking the professorships, 3527, 3528.

Examinations.
- Teaching in the colleges at Oxford is kept close to text-books, for examination purposes, 3465.
- In all the colleges at Oxford there are examinations, in subordination to the University examination; hardly any in natural science, 3499, 3500.
- Matriculation examination at Oxford University desirable; it should be organised in a liberal spirit; science could not be included at present, 3536–3539, 3563–3568, 3573.

Fellowships.
- Desirability of instituting, at Oxford, independent lectureships connected with fellowships, 3489–3491.
- Many colleges at Oxford are overburdened with fellowships; non-resident fellowships, granted as rewards, might be limited to ten, and resident teaching fellowships increased, 3503–3509, 3550–3552.
- Non-resident fellowships at Oxford have proved a powerful stimulus to education, 3506.
- Great uncertainty about the vacancies in fellowships at Oxford, 3520.
- Competition for science fellowships at Oxford lies among a small number of good men, 3521.
- If professorships at Oxford were combined with fellowships, they would be greater objects of attraction, 3523–3528.
- Christ Church is the only Oxford college where fellowships are appropriated to lectureships or demonstratorships; colleges generally should be compelled to follow this system, 3546, 3547.
- To promote original research at Oxford, the University laboratories should be available to men with degrees and fellowships, 3530, 3531.

Geometry.
- Savilian professorship of geometry at Oxford; includes the whole domain of pure mathematics, which is too much for one professor; its emoluments, lectures, &c., 3470–3476.
  - See *Mathematics.*

Government.
- The Council of the Royal Society would be the best scientific adviser of the Government, 3511, 3512.
- Desirability of valuable scientific apparatus being formed by Government, and lent for special research, 3543–3545.

Government Grant Committee (Royal Society).
- Approval of system of committee; the grant might be slowly increased, 3511–3513.

Grants for Science Purposes.
- Grants from New College, Oxford, in aid of Savilian professorships, 3472–3474.

Honours.
- About 20 Oxford students go out annually in mathematical honours, 3466–3468.
  - See *Degrees.*

SMITH, H. J. S., Esq.—cont.

Laboratories.
- To promote research at Oxford, the University laboratories should be available to men with degrees and fellowships, 3530, 3531.
- Colleges at Oxford could not supervise laboratory work, 3571.

Lecturers.
- Every college at Oxford has a mathematical lecturer, and the teaching is usually good, 3464.
  - See *Assistant Professors.*

Lectures.
- Number of lectures prescribed for Savilian professorships at Oxford; they are not confined to university students, 3475, 3476.
- At Oxford, more lectures are wanted on natural philosophy than the Sedleian professor is able to give, 3479, 3480.
- Exemption of a professor from giving lectures most undesirable, 3495.

Lectureships.
- At Oxford, independent lectureships would be more desirable than sub-professorships, 3489–3491.
- Colleges at Oxford should be compelled to appropriate fellowships to lectureships; Christ Church the only place where this done, 3546, 3547.

Lee's Readerships (Oxford).
- No Oxford fellowships are appropriated to lectureships, excepting the Lee's readerships, 3546.

Literature.
- Teaching in literature, as well as in science, requires extension, 3551.

Mathematics.
- The colleges at Oxford provide good teaching in mathematics, and more mathematics than natural science; the teaching has something of a "grinding" character, 3464, 3465.
- About 20 students at Oxford go out annually in mathematical honours; number slowly increasing, 3466–3468.
- Great improvement in mathematical education at Oxford in the last 20 years, 3468, 3469.
- Three mathematical professorships at Oxford; another chair of pure mathematics should be established; geometrical subjects should be divided from pure analysis, 3470, 3471, 3558.
- Allusion to Mr. Scott Russell's assignment of four professors to subjects represented by pure mathematics, 3471.
- Emoluments, &c. of Savilian professorships at Oxford, 3472–3477.
- Mathematical mechanics should be separated, in teaching, from mathematical physics, 3480.
- Students who enter Oxford Museum should have been well prepared in elementary mathematics by the colleges, 3569.

Matriculation.
- Matriculation examination, organised in a liberal spirit, is desirable for Oxford University; science could not be included, 3536–3539, 3563–3568, 3573.

Mechanics.
- Students who enter Oxford Museum should have been well prepared by the colleges in elementary mechanics, 3569.

New College (Oxford).
- Grants from New College in aid of Savilian professorships, 3472–3474.

Original Research.
- Small inducement at Oxford to pursue original research; if encouraged, students would readily devote themselves to it, 3484, 3485, 3529.
- Government might form a collection of valuable scientific apparatus, and render it available for research, 3543–3545.
- To promote research at Oxford, emoluments should be offered which would attract first class men; professors should have more time, and the laboratories should be available to men with degrees and fellowships, 3529–3531, 3553–3557.

Oxford University.
- Colleges at Oxford; teach more mathematics than natural science; teaching is kept close to examination purposes; improved mathematical instruction; approval of college system; examinations—few scientific; are overburdened with fellowships; should appropriate fellowships to lectureships; should supply tutorial instruction in concert with museum, 3464, 3465, 3468, 3469, 3496–3499, 3546, 3547, 3569–3573.

Smith, H. J. S., Esq.—*Oxford University*—cont.

Oxford students; about 20 go out annually in mathematical honours; number slightly increasing; their present tendency to science, 3466–3469, 3532, 3533.

Oxford professorships; Savilian and Sedleian; subdivision wanted in subjects of mathematics, physiology, &c.; emoluments; should be combined with fellowships; lectures, 3469–3477, 3479, 3480, 3486–3488, 3527, 3528, 3558–3560.

Appliances for teaching astronomy wanted at Oxford, 3177, 3178.

Objection to Oxford University being made a technical school, 3481, 3482.

Original research at Oxford; inducement wanting to pursue it; want of time of professors; University apparatus should be provided, 3483–3485, 3529–3531, 3553–3557.

Doubts as to system of head professors, with sub-professors under them, working satisfactorily, 3489.

Oxford professors; necessity of their having demonstrators; objection to their exemption from lecturing; incomes; appointment; want of pensions, 3489–3491, 3495, 3501–3505, 3510–3518, 3522–3526, 3553.

Oxford assistant professors; demonstrators essential to professor; may hereafter be supplied from the colleges; their duties might be assigned to fellowships, 3489–3494.

Oxford fellowships; ten non-resident fellowships a year might be allotted as rewards, and the rest applied to teaching; uncertainty about vacancies; competition for science fellowships is among a few good men, 3505–3509, 3520, 3521, 3550–3552.

Ecclesiastical element at Oxford too predominant in some boards, 3519.

Increase of tendency towards science at Oxford, 3532, 3533.

Degrees at Oxford; science degrees would not be of primary importance, 3534, 3535.

Matriculation examination at Oxford desirable; science could not be included, 3536–3539, 3563–3568, 3573.

Lee's readerships at Christ Church; the only instances where fellowships are devoted to lectureships, 3546.

Desirability of having a central power in the University for regulating grants of money, &c., 3548, 3549.

Importance of University being able to command the services of the best men, 3554–3556.

Physics.

Mathematical physics should be taught distinctly from mathematical mechanics, 3480.

Additional professors of physics are wanted at Oxford, 3487.

Students who enter Oxford Museum should have been well prepared by the colleges in elementary physics, 3569.

Physiology.

Additional professors of physiology are required at Oxford, 3487.

At Oxford, the subject of biology might be divided into morphology and physiology, 3560.

Practical Instruction.

A professor who gives practical instruction should have a demonstrator, 3489–3491.

Savilian professors of astronomy at Oxford have always desired to give practical instruction, 3477, 3478.

Professors.

At Oxford there is an essential difference between the teaching by professors and that by tutors in colleges, 3465.

Savilian and Sedleian professors at Oxford; emoluments, lectures, &c., 3470, 3472–3477.

Additional professors of physiology, chemistry, and physics wanted at Oxford, 3486–3488.

Demonstrators essential to a professor who gives practical instruction; lecturers more desirable than sub-professors, 3489–3491.

Great objection to professors being exempted from lecturing duties, 3495.

Payment of professors at Oxford ought to be, and is, by endowment; many professors do not take their fees; University cannot increase endowment; doubts of augmentation of endowment keep back first-rate men, 3501, 3502, 3527, 3528.

Colleges at Oxford aid stipends of professors; they might further assist by fellowships, 3503–3509.

Divinity professors at Oxford have the advantage in point of stipend, 3510.

600*l*. to 1,000*l*. an adequate endowment for a professor, or 600*l*. and a fellowship, 3512, 3553.

Smith, H. J. S., Esq.—*Professors*—cont.

Appointment of professors at Oxford; present system unsatisfactory; typical board of election suggested; local professors should be on the board, but in a minority, 3513–3518.

At Oxford, there is no retiring pension for professors, as there should be; present system of allowing the new professor to be taxed for the old is objectionable, 3522–3526.

To promote research at Oxford, professors should be offered good emoluments, and sufficient assistants and apparatus, 3530, 3553–3557.

Present tendency towards science at Oxford due to excellent teaching of natural science professors, 3533.

Elementary instruction in science given by professors is a waste of power, 3569–3573.

Professorships.

At Oxford, there are three mathematical professorships; another is wanted; also other chairs of physiology, chemistry, and physics, 3470, 3471, 3486–3488, 3558, 3560.

Savilian professorships of geometry and astronomy; emoluments, lectures, &c., 3472–3477.

Sedleian readership; number of subjects assigned to it is too large, 3479, 3480.

At Oxford, independent lectureships would be preferable to sub-professorships; might be connected with fellowships, 3489–3494, 3527, 3528.

Appointments to Oxford professorships; typical board suggested, 3513–3518.

Uncertainty of endowment being augmented keeps first rate men from professorships at Oxford, 3527, 3528.

Professorship of biology at Oxford should be subdivided into morphology and physiology, 3560.

Professorship of botany at Oxford not sufficiently connected with studies of University, 3560, 3561.

Royal Society.

Council of Royal Society the best scientific adviser of Government, 3541, 3542.

Russell, Mr. Scott.

Allusion to his assigning four professors to subjects represented by pure mathematics, 3471.

Salaries.

600*l*. to 1,000*l*., or 600*l*. and a fellowship, an adequate income for a professor at Oxford, 3512, 3553.

Savilian Professorships (Oxford).

Savilian professorships of geometry and astronomy; emoluments; lectures, 3470, 3472–3477.

Archbishop of Canterbury, Lord Chancellor, &c. elect to Savilian professorships; science not represented in the board, 3515, 3516.

Science.

Only three or four colleges at Oxford give systematic instruction in natural science; few examinations, 3464, 3500.

Mathematical education at Oxford University; improvement in the last twenty years; professorships, &c., 3468–3476.

Technical science should not be taught at Oxford University, 3481, 3482.

Were funds at Oxford University greater than they are, they would probably not be applied to natural science, 3502.

Present tendency at Oxford is towards science, especially in younger men, 3532, 3533.

Degrees in science not desirable for Oxford University, 3534, 3535.

Not teaching in science only, but also in literature, requires extension, 3551.

Matriculation examination for Oxford University could not include science, 3563–3568.

Elementary instruction in science, &c. should be given in the colleges at Oxford, not in the museum, 3569–3573.

See *Original Research. Professorships.*

Sedleian Readership (Oxford).

Sedleian readership of natural philosophy; too many subjects assigned to this chair, 3470, 3479, 3480.

Students.

At Oxford, about 20 students go out annually in mathematical honours; number slowly increasing, 3466–3468.

Lectures of Savilian professor at Oxford are not confined to students, but few others attend, 3476.

Oxford students would pursue research were inducement offered; the laboratories should be available to those with degrees and fellowships, 3483–3485, 3530, 3531.

Smith, H. J. S., Esq.—*Students*—cont.
Advantage to Oxford students of college system, with respect to residence, 3497.
Science students in colleges at Oxford are so few, that examinations have not been organised, 3500.
Competition for science fellowships at Oxford is among a few good students, 3521.
Tendency to science shown by Oxford students, 3533.
Matriculation examination at Oxford, liberally organised, would not lessen attendance of students, 3536–3539.
Students who enter museum of Oxford should have been well prepared by the colleges in elementary science, 3569, 3570.

Superannuation.
No retiring pension for professors at Oxford; desirable there should be, 3522–3526.

Technical Instruction.
Oxford University might render better service to science than by seeking to become a technical school, 3481, 3482.

Tutorial Instruction. See *Oxford University.*

BRODIE, Sir BENJAMIN COLLINS, Bart., M.A., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
Liberal accommodation for science teaching provided during the last 10 years by Oxford University, 3583.
Extension of scientific collections at Oxford University desirable; additional buildings would be requisite, 3590.

Age of Science Students.
Sound elementary training in science might be given to boys of 12 to 17 years, 3639.

All Souls' College (Oxford).
A non-educational foundation; it has no students, except a Bible clerk or two, 3667.

Apparatus for Science Purposes.
Liberal provision for scientific appliances made during the last 10 years by Oxford University, 3583, 3584.
At Oxford University there should be a common scientific fund, out of which to provide apparatus, &c., 3595.

Assistant Professors.
No difficulty in providing demonstrators at Oxford University, if colleges will give the money, 3618.

Astronomy.
Radcliffe observer at Oxford simply does astronomical work; he gives no lectures, but publishes tables of the stars, &c., 3596, 3651–3653.

Boards of Appointment. See *Election of Professors.*

Bodleian Library (Oxford).
One of the most valuable libraries in the world, 3589.

British Museum.
Institutions like the British Museum should exist in universities, both for educational purposes and for pure science, 3588, 3619, 3650.

Cambridge University.
For promotion of science, the college endowments at Cambridge should be again subjected to parliamentary influence, 3608.

Chemistry.
A sufficient staff, and certain amount of leisure for research, is allowed the professor of chemistry at Oxford, 3621, 3622.
Chemistry is taught in several colleges at Oxford; at Christ Church there is a laboratory, exclusively for students, 3654–3658.
The professorship of chemistry at Oxford was founded by aggregation of fellowships in Magdalen College; this system might be extended, 3608.
Of unattached Oxford students, only one attends the laboratory of the professor of chemistry, 3685–3687.

Children.
Through want of scientific training when boys, students enter universities ill-prepared, 3557.
Boys in endowed schools are not to study Greek, and universities are recommended not to insist on Greek for degrees, 3578, 3579.
Undesirable to separate literature from science in the instruction of boys, 3634–3638.
Schoolboys between 12 and 17 years of age might receive sound elementary training in science, 3639.

Christ Church College (Oxford).
Chemical instruction at Christ Church; small laboratory recently instituted, 3654–3658.

Colleges at Oxford. See *Oxford University.*

Brodie, Sir B. C., Bart.—cont.

Degrees.
Approval of Greek not being insisted on for degrees in universities, 3578, 3579.

Education.
Sacrifices are made now for education, but the preservation and extension of scientific knowledge is neglected; different case formerly, 3575, 3576, 3585, 3586.
Difficulties of scientific, as contrasted with literary, education, in universities, 3577.
Educational bodies demand too much from students, 3578.
The means of a higher education should be in advance of the demand in universities, 3582, 3626–3629.
No educational body has so much advanced science in the last 10 years as Oxford University, 3583, 3584.
Laboratory instruction is a function of education of the highest importance, 3593.
Oxford fellowships do not to any great extent promote education, even in Oxford itself, 3608.
Reservation of fellowships as prizes at Oxford would stimulate education; re-distribution of collegiate endowments wanted, 3609, 3659–3671.
In a matriculation examination at Oxford, all forms of education should be recognized, 3613, 3614.
If the want of early education were rectified, cultivators of science would be largely increased, 3627.
For general education, literature and science should not be separated in early training, 3634–3637.
Science training should form part of all primary education, 3638.
University colleges were not originally educational bodies, but associations for learning and religion, 3667.

Election of Professors, &c.
Constitution of Radcliffe trustees' board of election, 3598, 3599.
Scientific appointments should be made by a small board of persons who understand the subject; type of board suggested; objection to cliquism, 3601–3604.
Objection to convocation making appointments to scientific boards, 3602.
There should be special boards of appointment for each professorship, with persons on the board unconnected with the University, but connected with science, 3603–3605.
Desirability of occasionally electing eminent foreigners to professorships in English universities, 3606, 3607.
The Oxford University Commission allowed colleges to elect any professor to a fellowship, 3680.

Endowed Schools' Commission.
Commission recommends universities not to insist on Greek for degrees; boys in endowed schools being thereby excluded from universities, 3578, 3579.
Separate science schools, as proposed by Commission, may answer in special cases, but would be objectionable universally, 3634–3636.

Endowments.
For promotion of science, collegiate endowments must again be subjected to parliamentary influence; re-distribution favourable to science is wanted; opinions are tending in that direction, 3608, 3659–3671, 3683, 3684.
Allusion to book respecting alteration of collegiate endowments, written by the Rector of Lincoln College, 3683.

England.
The imperfect education of the English public in scientific matters is an impediment to science at Oxford University, 3577.

Examinations.
Fellowships were given by their founders for promotion of knowledge, and not as prizes after examination, 3608.
Matriculation examination, with considerable option given, would be desirable at Oxford University, 3613, 3614.
Of the 73 unattached students at Oxford University, 12 only have passed their moderations, 3687.

Fellowships
At Oxford, fellowships were formerly awarded without reference to merit; the University Commission altered this; they do not promote education, 3608.
Fellowships were never intended for prizes after examinations, but for promotion of knowledge; a certain number might be retained as prizes, 3608, 3609.
Professorships founded by aggregation of fellowships at Oxford; this system should be extended, 3608.

Brodie, Sir B. C., Bart.—*Fellowships*—cont.

Oxford fellowships, being mostly given for the older studies, are prevented from assuming their proper position; they are rarely given for science, 3612, 3678.

The existing mechanism of fellowships at Oxford cannot be utilized for professorial purposes, 3659–3671.

Fellowships at Oxford terminate on marriage; but the University Commission allowed colleges to elect any professor to a fellowship, 3679, 3680.

Foreigners.

Eminent foreigners might be occasionally appointed to professorships at Oxford University, 3606.

Funds of Universities, &c. See under *Contributions, Grants, &c.*

Germany.

Advantage to students of pursuing scientific investigation under professors in laboratories, as exemplified in Germany, 3593.

Grants for Science Purposes.

Liberal grants for science purposes made by Oxford University during the last 10 years; unlikely to be increased, 3583, 3584.

Colleges at Oxford might be made to contribute to a common scientific fund, at disposal of curators appointed by University, 3595, 3672–3675.

Liberal grants for science made by Radcliffe trustees at Oxford, 3596–3600.

Greek.

Approval of Greek not being insisted on for university degrees, 3578, 3579.

Headships of Colleges. See *Oxford University.*

Income.

The revenues of the colleges at Oxford are enormous; property increasing; will ultimately be perhaps 100,000*l.* a year; fellowships amounting to about 75,000*l.*, and headships of colleges to 20,000*l.*, 3608–3611.

Laboratories.

Laboratory work is an educational function of the most important character, 3593.

Professors should have laboratories for research, and should educate therein a limited number of students, who would enter partly as pupils and partly as assistants, 3593, 3624.

Small chemical laboratory recently erected at Christ Church College, Oxford; for students exclusively, 3654–3657.

Of unattached Oxford students, there is only one in laboratory of professor of chemistry, 3685–3687.

Lectures.

Professors, who pursue scientific investigation, should also give lectures, 3593.

No lectures are given by the Radcliffe observer at Oxford, 3596.

Lectures on chemistry given at Oxford; those at Christ Church are open to members of other colleges, 3654–3658.

Lee, Dr.

Chemical laboratory at Christ Church College, Oxford, recently erected out of Dr. Lee's fund, 3654–3657.

Libraries.

The libraries at Oxford and Cambridge could only have been founded for the sake of the preservation of knowledge itself, 3586.

For the purposes of pure science, universities should found great libraries, 3588.

Bodleian library at Oxford one of the most valuable in the world; Radcliffe library an important scientific library, 3589.

Literature.

For training in early life, literature should not be separated from science, 3634–3639.

Lyttelton, Lord. See *Endowed Schools' Commission.*

Manufactures.

Manufactures, by offering remunerative scientific employment, are impediments to science; a more general appreciation of science would rectify this, 3587, 3642–3648.

Magdalen College (Oxford)

The professorship of chemistry at Oxford was founded out of an aggregation of fellowships in Magdalen College; this method might be carried farther, 3608.

Marriage of Fellows.

Colleges at Oxford could not relieve fellows from obligation of celibacy; fellowships terminate on marriage; University Commission gave colleges power to elect any professor to a fellowship, 3679, 3680.

Brodie, Sir B. C., Bart.—cont.

Matriculation.

Matriculation examination, with considerable option given, would be desirable at Oxford University, 3613, 3614.

Medicine.

Scientific education of medical men is inadequate; science should be studied before entering the hospital, 3580.

A definite scientific career at universities would attract more students of medicine, 3581.

Merton College (Oxford).

The professorship of physiology at Oxford was founded by an aggregation of fellowships in Merton College; this system might be extended, 3608.

Chemical lectures given at Merton College, 3654.

Meteorology.

An annual meteorological report is issued from Radcliffe Observatory, 3652.

Museums.

Universities should found great museums, for the purposes of pure science, 3583, 3649, 3650.

Original Research.

Extension of scientific knowledge is a proper object of a national university; not kept in view as formerly; dangers besetting scientific investigation, 3575, 3576, 3585–3587.

For promotion of science at Oxford University, means of subsistence should be provided for professors devoted to research; there should be a scientific fund, controlled by curators, 3590, 3595, 3672–3675.

Oxford University should have power to found special professorships for research, but not entirely distinct from teaching, 3591, 3592, 3624, 3625.

Professors for research should have control of laboratories, and take students therein for instruction; time for research should be allowed them, 3593, 3630.

A sufficient staff, and a certain amount of leisure for research, is allowed to the professor of chemistry at Oxford University, 3621, 3622.

Oxford University.

Advancement and increasing appreciation of science at Oxford University during last 10 years; aid given will not extend much farther, 3583, 3584, 3676, 3677, 3687, 3688.

Extensive libraries, museums, and collections should exist at Oxford, for purposes of pure science; Oxford has the basis of such institutions, 3588, 3589, 3649, 3650.

Oxford professors; provision should be made for men devoted to research; separation between teachers and investigators not desirable; should not give rudimentary instruction; should be appointed according to University requirements, 3590–3595, 3616–3620, 3623, 3624, 3630, 3659.

Election of Oxford professors; small board of appointment desirable; convocations should not appoint to boards; special boards for each professorship wanted, 3601–3605.

Eminent foreigners might be occasionally appointed to professorships at Oxford, 3606, 3607.

Professorships founded by aggregation of fellowships at Oxford; this system should be extended, 3608.

Headships of colleges at Oxford are worth about 20,000*l.* a year, 3608.

Colleges at Oxford; endowments should be re-distributed byParliament; revenues enormous, and increasing; little tuition given; are reverting to system of professors; must assist University; might contribute to a common fund, found University professorships, or associate professorships with headships of colleges, 3608–3611, 3615–3619, 3672–3675, 3678, 3681–3684.

Oxford fellowships; some might be retained as prizes; existing mechanism of fellowships cannot be utilized for professorships; mostly given for older studies, rarely for science; terminate on marriage; colleges are allowed to elect any professor to a fellowship, 3609, 3612, 3659–3671, 3678–3680.

Matriculation examination, with considerable option given, desirable at Oxford, 3613, 3614.

Oxford Museum works in harmony with the tutors of the colleges, 3620.

Special collegiate scientific instruction at Oxford unlikely to be valuable; not worth while for a college to erect buildings, &c., for only a few students; centralized instruction desirable, 3620, 3631–3633.

Chemical teaching at Oxford; taught in several colleges; laboratory at Christ Church, 3621, 3622, 3654–3658.

The teaching power at Oxford should be in advance of the duties which it has to fulfil, 3628, 3629.

Brodie, Sir B. C., Bart.—*Oxford University*—cont.
All Souls' College, a type of a non-educational body, 3667.
Unattached students at Oxford; now 73 in number; only one of them in the laboratory of the professor of chemistry, 3685–3687.

Oxford University Commission.
The Commission compelled colleges to recognize merit in awarding fellowships, and allowed them to elect any professor to a fellowship, 3608, 3680.

Parliament.
Parliamentary influence should be brought to bear on redistribution of collegiate endowments; indications of feeling in that direction, 3608, 3659–3671, 3681–3684.

Physiology.
Professorship of physiology at Oxford founded by aggregation of fellowships in Merton College; this system might be extended, 3608.

Practical Instruction.
Scientific should be separated from practical instruction in universities, 3580.

Professors.
Oxford University should provide means of subsistence and leisure for professors engaged in scientific research; these should lecture, and superintend laboratories, 3590, 3595, 3630.
There should be professors for teaching and professors for investigating at Oxford, but not absolutely separated: the two functions are too intimately associated now, 3590–3595.
Oxford professors should be appointed for individual sciences, 3590–3595, 3624, 3625, 3659–3671.
Colleges at Oxford are reverting to professorial system; most of the scientific instruction is in the hands of the professors, 3616–3620.
At Oxford, the Radcliffe observer gives no lectures; he simply does astronomical work, 3596.
Election of professors: type of board of appointment; special boards for different professorships desirable; eminent foreigners might be occasionally elected, 3601–3607.
The Oxford University Commission allowed colleges to elect any professor to a fellowship, 3680.

Professorships.
Liberal provision of scientific professorships made by Oxford University during the last 10 years, 3583.
A variety of scientific professorships, with different functions attached to them, desirable for Oxford University, 3594.
Appointments to professorships at Oxford; type of board; eminent foreigners might be appointed, 3601–3606.
Oxford professorships founded by aggregation of fellowships; system should be extended, 3608.
Oxford University should not fill up professorships, unless competent men are found; it should create professorships for individual sciences, 3624, 3625, 3659–3671.
For science purposes, colleges at Oxford might found University professorships within the colleges themselves, or might associate professorships with headships of colleges, 3672–3675.

Radcliffe Library (Oxford).
Radcliffe Library a most important scientific library; entirely supported by Radcliffe trustees, 3589, 3600.

Radcliffe Observatory (Oxford).
Radcliffe Observatory a noble type of a scientific institution, publishes tables of stars, meteorological reports, &c., 3596–3600, 3651–3653.

Radcliffe Trustees (Oxford).
Liberal grants for science made by Radcliffe trustees; the trustees choose one another, and are not necessarily members of the University, 3596–3600.

Revenues. See *Income.*

Salaries.
A proper stipend is essential to secure a good professor, 3595.

Schools.
In view of endowed schools, in which Greek will not be studied, it is desirable that universities do not insist upon it for degrees, 3578, 3579.
Separate schools for science, as proposed by Endowed Schools' Commission, are desirable only in special cases, 3634–3636.
Literature and science should be taught together in schools; at 17 years of age there should be a branching off, 3637–3639.

Brodie, Sir B. C., Bart.—cont.

Science.
Scientific investigation a proper object for a national university; not kept in view now; dangers besetting it, 3575, 3576, 3585–3587.
Universities are available for the purposes of science in its widest sense, 3575.
Difficulties of scientific education in universities; boys not being trained in science, students enter ill-prepared; public are inappreciative, 3577.
A definite scientific, as distinguished from a literary career, should be instituted at universities, 3578, 3581.
Medical and other scientific schools cannot compete with universities; medical students might have University course abbreviated, 3580, 3581.
In universities, science should be studied without immediate reference to practice, 3580.
Oxford University has done more for science of late than any educational body in this country; appreciation of science there is increasing, 3583, 3584, 3676, 3677.
Impediments to science; profits from manufactures attract capable men; reasonable existence for scientific men not given; pursuit of science unremunerative, 3586, 3587, 3612–3618.
Institutions like the British Museum should exist in universities for the purposes of pure science, 3588.
The functions of science teacher and investigator are too intimately associated; but absolute separation would be undesirable, 3591.
High importance of laboratory instruction, which carries to its end scientific education, 3595.
Radcliffe Observatory a noble type of a scientific institution, 3597–3600, 3651–3653.
In election of professors, there should be on the board individuals connected with the science, whose opinions would have a real value, 3605.
For training in early life, literature and science should not be separated, 3634–3639.
Scientific training should form part of all primary education, 3638.
Were science better understood, many persons of leisure would pursue it as an interesting occupation, 3689, 3690.
See *Oxford University.*

Science Schools.
Medical and other special scientific schools cannot possibly compete with universities, 3580.
Objection to separate science schools, except in special cases, 3634–3639.

Students.
Through want of scientific training when boys, students enter universities ill-prepared, 3557.
Medical students; should have adequate scientific knowledge before entering hospitals; a definite scientific career at universities would attract them, 3580, 3581.
Importance to students of pursuing scientific research in laboratories, 3593.
Sound elementary training in science might be given to boys between 12 and 17 years of age, after which branching off should take place, 3639.
Unattached Oxford students; 73 in number; only one in laboratory of professor of chemistry; 12 only have passed their moderations, 3685–3687.

Tutorial System. See *Oxford University.*

Universities.
Universities are available for promoting scientific education, and for preserving and extending scientific knowledge; the last is not sufficiently kept in view, 3575, 3576, 3585, 3586.
Difficulties of scientific education at universities arise from ignorance; boys are not taught science, and students come ill-prepared, 3577.
Approval of Greek not being insisted on for University degrees, 3578, 3579.
Medical schools, &c., cannot compete with universities; a definite University scientific career would induce more students to attend, 3578, 3580, 3581.
In universities, means of higher education should be in advance of demand, 3582, 3626.
Universities should have libraries and scientific collections on the scale of the British Museum, 3588, 3649, 3650.
In English universities, eminent foreigners might occasionally be appointed, 3606, 3607.
Universities should be, not local, or even national, but agents for extension of knowledge, 3606.

PATTISON, THE REV. MARK, B.D. (Index of his Evidence.)

Accommodation for Science Purposes.
Oxford Museum, laboratories, &c. maintained, at large cost, by University, 3787.

Affiliation of Colleges. See *Oxford University.*

Arbiturienten-Examen. See *Germany.*

Assistant Professors.
Oxford men, remaining in the University, might become tutors, sub-professors, and professors; provision should be offered them, 3807.
System of professors and sub-professors would work smoothly in practice, 3808.
Objection to examinations at Oxford University being conducted by répétiteurs, 3823-3826-7.
Sub-professors at Oxford should be chosen from promising students; they should have 300*l.* or 400*l.* a year, and be independent of the professors, 3833, 3834.

Astronomy.
Pure mathematics, including astronomy, should form one class of an honours' school for degrees at Oxford University, 3771-3781.

Balliol College (*Oxford*).
Balliol College provides its own instruction in every branch, 3840.

Biology.
Biology (comprising physiology and morphology) should form one class of an honours' school at Oxford University, 3771-3781.
Chair of physiology at Oxford University should be divided; two leading professors requisite, 3810, 3817.

Board of Studies. See *Oxford University.*

Botany.
Botany could not be included in a degree examination at Oxford University; it might be encouraged by scholarships and fellowships, 3781.
There is only one professor of botany at Oxford University, 3817.

Cambridge University.
At Cambridge, there is a board of studies, consisting of professors; a separate board for science will be essential, 3835, 3836.

Chemistry.
Chemical sciences (comprising heat and light treated chemically, electricity, magnetism, mineralogy, and crystallography) should form one class of an honours' school at Oxford University, 3771-3781.
Subject of chemistry should be divided at Oxford University; three leading professors hardly sufficient, 3810, 3817.

Christ Church College (*Oxford*).
Christ Church provides its own instruction in every branch, 3840.

Cost, Income, and Expenditure.
Cost of Oxford Museum, exclusive of professors, is about 2,000*l.* a year, 3787.
College funds at Oxford are sufficient to provide for extension of science teaching, without trenching upon literary side, 3787.
About 35,000*l.* is spent annually at Oxford on scholarships and exhibitions, 3801.
Some colleges at Oxford have incomes of 20,000*l.* to 40,000*l.* a year; Lincoln College has about 6,000*l.*, 3867.
See *Salaries.*

Degrees.
Divided opinion at Oxford University respecting Greek for degrees; approval of all literary instruction being detached from scientific, 3754.
London University examination for degrees combines science with classics simultaneously; the Oxford examination, consecutively, 3755.
For science degrees at Oxford, a specialized examination, in four classes, is desirable; passing in honours in any class sufficient; standard of fourth class not to be higher than first B.A. of London University, 3771-3774, 3776-3779.
Masters or Bachelors of Arts for the Oxford classical curriculum, and Masters or Bachelors of Science for the scientific curriculum, would be desirable designations; Mastership of Science might lead up to Doctorate, 3775, 3783, 3784.
Oxford examinations for science degrees should include pure mathematics, physics, physiology, and chemistry; facilities might be offered for technical branches, 3780-3785.

PATTISON, The Rev. M.—*Degrees*—cont.
Objection to zoology, botany, geology, and physical geography, as subjects of examination for Oxford degrees, 3781.
Oxford fellowships were originally for students who had taken B.A., and were working for M.A. degree, 3789.
Men with degrees at Oxford University might leave for professions, or remain as teachers; a career and provision for the latter should be made, 3807.
Majority of candidates for London University B.A. degree enter themselves as "private study," 3850.
Oxford University might give a better degree than the composite degree of the London University, 3857.
Value of examination for B.A. degree at Oxford is below appreciation; if many are plucked, more come next time, 3875-3883.

Education.
Scientific can be combined with literary education, either simultaneously or consecutively, 3755.
An amount of culture sufficient for an English career may be obtained from science without literature, as well as from literature without science, 3830.
Real culture must be founded on specialization, 3853.
Bad results from separate literary and scientific education, as exemplified in Germany; but German system preferable to French, 3855, 3856.
Sufficient thoroughness not attainable from literary education alone; scientific idea wanting, 3860.

Endowed Schools' Commission.
Division of opinion at Oxford respecting proposition of Commission, that degrees might be obtained without Greek, 3754.

Endowments.
Oxford endowments; more applied to classics than necessary; they are passing from literary to scientific side; parliamentary interference essential, 3789-3796, 3815, 3840-3845.
Highest endowed professorship at Oxford about 1,000*l.*; on science side, 800*l.*; latter insufficient, 3812.
Professors receiving college endowments should reside in college; some might be allowed to teach elsewhere, 3825.
Oxford University endowment is the property of the English people, 3852.
See *Salaries.*

Examinations.
London University B.A. examination combines science with classics simultaneously; Oxford examination, consecutively, 3755.
Moderations at Oxford; mathematics required; diminution of classics proposed; will be put back to third or fourth term, 3755, 3756, 3839.
Objection to matriculation examination at Oxford University, 3759, 3846-3852.
First examination for Oxford students should be at end of first year; scientific examination should be elementary, and comprise mathematics, two sciences, and logic; no honours, 3760-3770.
Advantage of logic in examination for science degree, 3767-3769.
For science degree at Oxford, a specialized examination, in four classes, is desirable; passing in honours in any one class should be sufficient; competition for honours in any number of schools should be permitted, 3771-3774, 3776-3779.
Masters or Bachelors of Arts or of Science would be desirable designations for those passing the literary and scientific examinations at Oxford, 3775.
Science degree examinations at Oxford might be in pure mathematics, physics, physiology, and chemistry; zoology, botany, geology, and physical geography should be for extra prizes; technical branches might be included, 3780-3785.
Examinations for scholarships, open to all the world, would be desirable at Oxford University, 3804, 3825.
Narrow constitution of examinations at Oxford University the cause of bad attendance, 3820.
Desirability of professors, and not tutors, conducting examinations at Oxford, 3823-3826-7.
Examination test less perfect than college test, 3825.
German universities do not conduct preliminary examinations of their students; it is done by the Arbiturienten-Examen, 3828.
Examinations for B.A. degree at Oxford are in value below appreciation; if many candidates are plucked, more come to the examinations next time, 3875-3883.

Exeter College (*Oxford*).
Exeter College provides its own instruction in every branch, 3840.

PATTISON, The Rev. M.—cont.
Exhibitions. See *Scholarships and Exhibitions.*
Fellowships.
At Oxford, zoology, botany, geology, and physical geography might be encouraged by fellowships, &c., 3781.
Oxford fellowships were originally for students who had taken B.A., and were working for M.A. degree, 3789.
Owing to mode in which fellowships are given at Oxford, too many endowments are applied to classics; they are injurious to general study, 3789, 3822.
There are about 500 fellowships at Oxford, of 200*l.* to 300*l.* a year; under 100 are held by college officers, 3790.
Opinion at Oxford is in favour of a large suppression, but not abolition, of fellowships; it is considered necessary to retain some for classics, 3791–3793, 3821.
About 30 Oxford fellowships have been awarded for mathematical and physical science; endowment is slowly passing in this direction, 3794–3796.
Without any non-resident or prize fellowships, there would be the same amount of classical study at Oxford, 3799.
Fellowships should not be awarded for past attainments, but prospectively, for practical teaching, 3800.
Emoluments of suppressed Oxford fellowships should be devoted to encouragement of scientific research, 3832.
Merging of Oxford fellowships into life professorships cannot be effected without parliamentary interference, 3840–3845.
See also *Scholarships and Exhibitions.*

France.
French system of education comprises a little of everything, and nothing thoroughly, 3856.

Geology.
Geology could not be included in Oxford degree examination; it might be encouraged by scholarships, &c., 3781.
There is only one professor of geology at Oxford University, 3817.

Germany.
Preliminary examination of students entering German universities is conducted by a separate board, the Arbiturienten-Examen, 3828.
Sub-professors, like the German professor extraordinarius, are desirable at Oxford University, 3834.
Evil of separate literary and scientific culture more developed in Germany than here; but German system of education preferable to French, 3855, 3856.

Greek.
Division of opinion at Oxford as to abolishing Greek for degrees; approval of all literary instruction being detached from scientific, 3754, 3756.
Greek forms part of London University examination for B.A. degree, 3755.

Honours.
First years' examination for Oxford students should not comprise honours; degrees should be taken in an honours' school, and honours in any number of schools, 3770, 3779, 3782.

Income. See *Cost, &c.*

Lectures.
Combination of certain colleges at Oxford for lectures; the system raises the college tutor into a university officer, 3810, 3857.

Lincoln College (Oxford).
Income of Lincoln College is about 6,000*l.* a year; no surplus fund, 3867, 3868.

Literature.
Instruction in science, distinct from literature, should be instituted at Oxford University; at present, science is there combined with literature consecutively, 3754–3758.
Without touching on literature, college funds at Oxford are enough for extension of science, 3788.
At Oxford, too many college endowments are applied to classics; prize fellowships are considered essential to maintain classics, 3789, 3791, 3802, 3821, 3822.
There would be as much classical study at Oxford University if there were no non-resident fellowships, 3799.
Culture sufficient for an English career may be obtained from science without literature, as well as from literature without science, 3850.
Thoroughness could not be got from literary culture purely; scientific idea wanting, 3852–3861.

Logic.
Desirability of including logic in initial examination of Oxford natural science students, 3767–3769.

PATTISON, The Rev. M.—cont.
London University.
London University B.A. degree examination combines science with classics simultaneously, 3755.
Lowest class for honours at Oxford should not be higher than London University first B.A., 3779.
Approval of London University system of including logic in science degree examination, 3767–3769.
London University has, beyond the second B.A., the M.A., D.Sc., and medical examinations, 3783.
Non-resident students might be examined at Oxford on London University system, 3825.
A large proportion of London University candidates enter themselves as "private study," 3850.
Oxford might aim at giving a better degree than the composite degree of the London University, 3857.

Marriage of Fellows.
Formerly at Oxford, tutors, on marriage, lost tutorships and fellowships; necessity of alteration; professors should be enabled to marry and settle in the place, 3807, 3808.

Mathematics.
Mathematics is required for moderations at Oxford University, 3756.
In initial examination of Oxford students of natural science, competency in mathematics should be shown; it need not go beyond the calculus, 3762, 3763.
About 30 fellowships at Oxford have been awarded for mathematical and physical science, 3794.
Scholarships in mathematical and physical science at Oxford should be increased with the demand, 3805.
Pure mathematics, including astronomy, should form one class of an honours' school for degrees at Oxford, 3771–3781.
Three leading professors of mathematics desirable at Oxford University, 3817.

Matriculation.
Objection to matriculation examination at Oxford University, as a means of avoiding waste of time on subjects not afterwards studied, 3759, 3875–3883.

New College (Oxford).
New College provides its own instruction in every branch, 3810.

Original Research.
Great boon to Oxford University if 20 or 30 men devoted to scientific research could be appointed; they would attract students, 3811–3814.
Teaching functions of Oxford professors should be light, to set them free for original research, 3832.

Oxford University.
Divided opinion at Oxford University respecting necessity of Greek for degrees, 3754.
University should institute a course of scientific instruction, detached from literature; at present, science is combined with literature consecutively, 3754–3758, 3770, 3774, 3846–3852.
Examinations at Oxford; diminution of classes in moderations; moderations to be put back to third or fourth year; objection to matriculation examination; first science examination should be elementary—second, for degrees, specialized, in four classes; an annual examination for scholarships, open to everyone, desirable; examinations should be conducted by professors, not tutors, 3755, 3756, 3759–3785, 3801, 3826–3829, 3839, 3875–3883.
Degrees at Oxford; B.A. is given after two examinations; approval of designation of Master or Bachelor of Arts, or Master or Bachelor of Science; Mastership of Science might lead up to Doctorate; university gives degrees in medicine; small value of University B.A. examination, 3755, 3783, 3883.
Students at Oxford; objection to matriculation examination; bad attendance attributable to narrow constitution of examinations; university should be open to all students; unattached students can stand for scholarships, idle students a difficulty, but they should not be kept away, 3759, 3820, 3825, 3828, 3829, 3857, 3869–3883.
Zoology, botany, geology, and physical geography should be encouraged at Oxford by scholarships, &c., 3781.
Professors at Oxford; staff inadequate for extension of science; should have previously been tutors and sub-professors; professors and sub-professors would work well together; two professors of same part of same subject undesirable; 20 or 30 professors would be a great boon; professors are favourable to reduction of fellowships; teaching functions should be light; their provision should be sufficient for them to marry, and live in the place, 3786, 3807–3814, 3821, 3822, 3825, 3832.

PATTISON, The Rev. M.—*Oxford University*—cont.

Oxford University has spent large sums for scientific teaching; maintains Museum at a cost of 2,000*l.* a year, 3787.

Colleges at Oxford; possess ample funds; recent tutorial combination should become universal; objection to affiliation of colleges; parliamentary power required to re-distribute endowments; antithesis between college and university merely nominal; larger colleges carry off best men; colleges can suppress fellowships, and could substitute university scholarships for college scholarships, 3788, 3797, 3798, 3825, 3840–3845, 3862–3865, 3867, 3868, 3884–3886.

Fellowships at Oxford; more for classics than necessary; less than 100 out of 360 held by college officers; large suppression desirable; abolition of non-resident fellowships would not affect classics; should be awarded prospectively, for practical teaching, 3789–3796, 3799, 3800, 3821, 3822.

Scholarships and exhibitions at Oxford; small portion only for science; too many for classics; if increased now, candidates would be wanting, 3801–3806.

Evils of the old tutorial system at Oxford; tutorships and fellowships were lost on marriage; marriage of professors should be allowed, 3807, 3808.

Professorships at Oxford; graduated system desirable; chair need not be resigned when teaching is given up; income, 800*l.*, insufficient; professorships should be increased, 3807–3818.

Assistant professors at Oxford should be independent of professors, 3833, 3834.

Board of studies at Oxford; consists of principal professors; separate board of scientific studies will be essential, 3835, 3836.

Oxford University should be a head-quarters for furnishing teachers of science, 3838.

Literary and scientific culture at Oxford University; institution of a definite line of culture undesirable, 3852–3861.

Parliament.

A Parliamentary Commission (like that of 1854) is essential to deal with endowments of colleges at Oxford; doubtful if it should interfere with internal regulations, 3840–3845, 3862–3865.

Physics.

Physics (including mechanical philosophy, heat treated mechanically, optics, and acoustics) should form one class of an honours' school at Oxford, 3771–3781.

Physical Geography.

Physical geography could not be included in Oxford degree examination; it might be encouraged by scholarships, &c., 3781.

Physiology. See *Biology.*

Professors.

Present staff of Oxford professors inadequate to extended scientific teaching, 3786.

Graduated professoriate should be instituted in Oxford University; professors should have previously served as tutors and sub-professors, 3807.

Working together of professors and sub-professors would become smooth in practice, 3808.

A professor, released from his chair, need not be superannuated; a co-ordinate professor, to perform the duties, might be appointed, 3809.

Two professors of same part of same subject not desirable; but large subjects (as physiology and chemistry) might be divided, 3810.

20 or 30 professors at Oxford, promoters of scientific research, would be most desirable; their teaching duties should be light; students would be attracted, 3811, 3813, 3814–3817, 3832.

Highest endowment of science professors at Oxford is 800*l.*; insufficient, 3812.

Eleven mathematical and physical professors at Oxford; additional professors wanted in mathematics, physiology, chemistry, &c., 3817.

Collegiate funds, when set free, should go to increase stipends of professors, 3819.

The few students attending certain professors at Oxford is attributable to narrow constitution of examinations, 3820.

Most teachers at Oxford University would be in favour of reduction, but not abolition, of prize fellowships, 3791–3793, 3821, 3822.

Desirability of professors, and not tutors, being examiners at Oxford University, 3823–3826-7.

Professors, drawing salary from college endowments, should be located in university; but some might be allowed to teach elsewhere, 3285.

PATTISON, The Rev. M.—*Professors*—cont.

Senior professors at Oxford should have as many junior professors as expedient; the latter should be chosen from students; should be independent of professor, 3833, 3834.

At Oxford and Cambridge there is a board of studies, consisting of the principal professors, 3835.

Combined system of tuition at Oxford raises the college tutor into a university officer, 3840, 3887.

Professorships.

Graduated system of professorships desirable at Oxford University; need not be resigned on giving up teaching, 3807–3810.

Increased number of professorships wanted at Oxford, 3811.

Highest endowed professorship at Oxford is about 1,000*l.* a year; on science side, 800*l.*, which is insufficient; many are inadequately paid, 3812, 3818.

Merging of prize fellowships into life professorships at Oxford, could only be completed by a Parliamentary Commission, 3840–3845.

Salaries.

Proper salaries should be provided for the tutors, sub-professors, and professors, who would teach in Oxford University, 3807.

800*l.* a year is the endowment of the professorship of physiology at Oxford University; insufficient, 3812.

The first application of Oxford collegiate funds set loose should be to increase stipends of professors, 3819.

300*l.* or 400*l.* a year should be given to junior professors at Oxford University, 3833.

Scholarships and Exhibitions.

Zoology, botany, geology, and physical geography might be encouraged at Oxford University by scholarships, &c., 3781.

About 35,000*l.* a year is spent at Oxford on scholarships and exhibitions; a small portion only for science, 3801.

More Oxford scholarships are granted for classics than are required by the interest of classics, 3802.

Increased value of scholarships at Oxford, for securing the best students; formerly worth 40*l.*, now 90*l.* and 100*l.*, 3802, 3803.

A general annual examination for scholarships at Oxford University, open to all, desirable, 3804.

Mathematical and science scholarships at Oxford University might increase with demand; if increased now, proper candidates would be wanting, 3805, 3806.

Oxford University should induce students to enter, by offer of exhibitions, 3825.

Oxford scholarships are open to unattached students; a man is an unattached student because he is unequal to getting a scholarship, 3869–3874.

Colleges at Oxford have power to substitute university scholarships for college scholarships, 3884–3886.

Schools.

Objection to affiliation of schools with Oxford University; better to send out teachers to the schools, 3825.

Science.

A scientific course can be combined with literary training, either simultaneously or consecutively; at Oxford University, it is combined consecutively, 3755.

Classificatory sciences are not adapted to degree examinations, 3781.

From science without literature, as well as from literature without science, a sufficient amount of culture for an English career may be obtained, 3830.

Thoroughness could not be got out of literary culture purely; scientific idea wanting, 3852–3861.

See *Oxford University.*

Science Teachers.

Better to send out science teachers to colleges than to affiliate those colleges, 3825.

See *Professors.*

Students.

Before admission to B.A. examination at Oxford, students must have passed in moderations, 3755.

Students should be allowed to matriculate at Oxford in science alone, or both in science and classics, 3756–3758.

Objection to matriculation examinations for Oxford students; their first examination should be at end of first year, and elementary; and their last, for degrees, should be highly specialized, in four classes, 3759–3779, 3846–3851, 3875–3883.

Future students of natural science at Oxford should show acquaintance with mathematics and logic, 3762, 3763, 3767–3769.

Oxford students should be permitted to compete for honours in any number of schools, 3773, 3774.

PATTISON, The Rev. M.—*Students*—cont.

Students should be encouraged to study zoology, botany, geology, and physical geography, at Oxford, by scholarships, &c., 3781.

Fellowships at Oxford were originally for students who had taken B.A., and were working for M.A. degree, 3789.

About 35,000*l.* is annually spent on scholarships, &c. for students at Oxford; only a small portion goes to science students; general annual examinations, open to all students, desirable, 3801–3804.

Were Oxford scholarships increased now, qualified students to compete would be wanting, 3806.

Eminent teachers at Oxford University would attract students, 3811–3814, 3817.

The few students attending certain professors at Oxford is attributable to narrow constitution of examinations, 3820.

Undesirable that Oxford students should be examined by their own tutors, 3823, 3824.

Encouragement should be given to Oxford students to reside; but non-resident students should be admitted to examinations, 3825.

Science students entering Oxford University should have had literary training in schools; but testimony to that effect not to be required, 3828, 3829.

Promising students should be selected for junior professors at Oxford University, 3833, 3834.

Most students at Oxford study science with a view to professions; in future, they will be allowed to pass moderations earlier, 3837, 3839.

Unattached Oxford students can stand for scholarships; a man is an unattached student because he is unequal to getting a scholarship, 3869–3874.

Wealthy and idle students are a difficulty at Oxford University, but no one should be kept away, 3875–3883.

Superannuation.

A professor, released from his chair, need not be superannuated; a co-ordinate professor to perform the duties of the chair might be appointed, 3809.

Technical Instruction.

Oxford University might offer instruction in technical branches; this has not yet been done, 3785.

Tutorial System. See *Oxford University.*

Zoology.

Zoology could not be included in a degree examination at Oxford; it might be encouraged by awards of scholarships, &c., 3781.

Zoology is unrepresented at Oxford University, 3817.

JOWETT, REV. BENJAMIN, M.A. (Index of his Evidence.)

Accommodation for Science Purposes.

Accommodation for science purposes provided by Oxford University; more than 100,000*l.* spent in the last 12 years for buildings, &c., 3896, 3965.

Age of Students.

General education of students should go on to 21 or 22 years of age; this would gradually be narrowing into professional education, 3918.

Apparatus for Science Purposes.

Single colleges at Oxford might well furnish simple apparatus for instruction in science and art, 3890.

Excellent provision of physical science apparatus at Oxford University, 3896.

Balliol College (Oxford).

Laboratory and science teaching at Balliol College formerly; now given up; students go to museum, 3892.

Combination of Balliol and New Colleges for lecture purposes, 3953.

Children.

Greek should be continued in the principal public schools; all boys not being required to learn it, 3971, 3972.

Degrees.

Oxford degrees, with literary part taken away, would lose social value, 3897, 3917.

Objection to Greek being given up for degrees in universities, 3897, 3917.

Degrees at Oxford should not be granted without scientific attainment; small and exact amount of science, rather than general acquaintance with it, desirable, 3897–3916, 3924–3927, 3940.

JOWETT, Rev. B.—*Degrees*—cont.

After passing moderations at Oxford, a degree can be obtained without further study of classics; there should be no compulsion, 3919, 3920.

Present classical requirements for Oxford degrees should be maintained, 3930–3935, 3939–3942, 3973, 3974.

At Oxford University, degrees can be taken in science with a minimum of classics, or in classics with a minimum of science, 3932, 3933.

See *Honours.*

Education.

Education at Oxford University; great change in the last 20 years; alternation of University study and hospital study in London, &c. would be easy, 3890, 3964–3967.

Preliminary education should be general, that of after-life special, 3917.

Study of Greek could not be given up without serious loss to the higher education of the country, 3917.

Endowments.

Useless to set apart endowments for science at Oxford University without students to need them, 3890.

Oxford University has appropriated more than 100,000*l.* to endowments, &c. for science the last 12 years, 3965.

Engineering.

Engineering students at Oxford University might be admitted to honours, scholarships, and a free education; and obtain degrees, at any time, on passing the present examination, 3897–3902, 3936–3938.

Euclid.

Every Oxford undergraduate is required to know some Euclid, 3912.

Examinations.

Oxford degrees should not be given until all the examinations at present required have been passed, 3897–3902.

Objection to preliminary examination for entrance to Oxford University, 3901.

In moderations at Oxford, students must pass in classical or mathematical school; they can obtain a degree without further study of classics; physical science and modern history should be added, 3910, 3911, 3916, 3973, 3974.

Responsions at Oxford cannot be passed without mathematics; to the mathematics essential for Oxford degrees science should be added; examination in the latter being passed at any period, 3912–3915.

Fellowships and Scholarships.

Useless to set apart physical science scholarships and fellowships at Oxford University until students are created; those already set apart lose effect from want of regularity in filling up, 3890.

Greater proportion of scholarships, as compared with fellowships, desirable at Oxford University, 3890.

Physical science scholarships at Oxford are few, compared with those for other subjects; not few, compared with number of physical science students, 3891.

All Oxford students distinguished in physical or mathematical science would be likely to obtain scholarships or fellowships, 3891, 3903.

Colleges at Oxford act independently in respect to physical science fellowships or scholarships, 3892.

Students at Oxford qualified to take science scholarships are few, but more than formerly, 3894, 3895.

A temporary class of students might be instituted at Oxford University, who would be admitted to scholarships, not to fellowships, 3897–3902, 3927, 3928.

Oxford fellowships should be given for advancement of science, but not to candidates destitute of literature, 3943–3947.

Colleges at Oxford could provide yearly vacant fellowships and scholarships, but with difficulty; many would do it of their own accord in time, 3962, 3963.

Physical science scholarships at Oxford should be University, not collegiate, scholarships; they might be for students belonging to any college, 3968, 3969.

Oxford fellowships do good in supplying teachers, and passing young men into professions; should not be materially altered; colleges might apply funds to University without affecting fellowships, 3975.

More holders of Oxford fellowships should be employed in University teaching; the condition of celibacy must be got rid of, 3976.

Germany.

In German universities, literature, not science, is the attractive element, 3897.

Government.

A ministerial cabinet composed of persons knowing Latin and Greek would be better than one composed of chemists, 3948–3952.

JOWETT, Rev. B.—cont.

Grants in aid of Science.

To raise a collegiate scientific fund at Oxford would require parliamentary interference, 3958–3963.

More than 100,000*l.* has been appropriated to science by Oxford University the last 12 years, 3965.

Greek.

Greek should be essential for degrees in universities and higher schools; Greek literature of higher value than Latin, 3897, 3917, 3921–3923, 3974.

A Ministerial Cabinet of Latin and Greek scholars would be better than one composed of chemists, 3948–3952.

Study of Greek should be continued in the principal public schools; all boys not being required to learn it, 3971, 3972.

History.

Oxford candidates for science honours are in number not one fourth of those for law and modern history; pass-men not one in twenty, 3897.

Modern history should be on a level with physical science at Oxford University, and, together with science, should be added to moderations, 3907, 3916.

Honours.

Revival of professorial system of teaching, and combination of colleges, resulted from extension of honours' system at Oxford University, 3890.

Oxford students; candidates for honours do not increase; professional students should be admitted to honours; preponderance of history students over science students in honours, 3897, 3936–3938.

College combination at Oxford has been carried on for honours' purposes, but must be extended to pass-men, 3954.

See *Degrees.*

Income.

Revenues of colleges at Oxford amount to three fourths of whole University, 3890.

See *Grants in aid of Science.*

Laboratories.

Laboratory formerly at Balliol College, Oxford; now given up, 3892.

Increased number of science students at Oxford due to the laboratories, &c., 3895.

Latin.

Greek literature more valuable than Latin, 3922.

Latin should be demanded of every candidate for a degree, 3974.

A Cabinet of Latin and Greek scholars would be preferable to one composed of chemists, 3948–3952.

Law.

Oxford candidates for honours in science are few compared to those for honours in law and modern history, 3897.

Lectures.

Combination of colleges at Oxford University for lecture purposes, 3890, 3953–3955.

Literature.

Literature, not science, is the attractive element in universities, 3897, 3904–3907.

Oxford degrees would lose social value if literary portion were taken away; present classical requirements should be maintained, 3897, 3917, 3930–3935, 3939–3942, 3973, 3974.

Students might obtain scientific distinctions at Oxford University, with option of passing literary examination for degrees at any time, 3897, 3898.

Oxford students can pass in classics, without mathematics, at moderations, not at responsions; no further study of classics necessary; to moderations, physical science and modern history should be added, 3897, 3910–3913, 3916.

Literature is for the many—science for the few; neither should be pursued exclusively, 3917.

Greek is the greatest literature in the world; more valuable than Latin; should not be given up for degrees, or discontinued in public schools, 3897, 3917, 3921 3923, 3971, 3972.

Oxford fellowships should be given for advancement of science, but not to candidates destitute of literature, 3943–3947.

Latin and Greek more valuable than chemistry to Cabinet ministers, 3948–3952.

London.

Medical students at Oxford University might alternate their studies with hospital instruction in London, &c., 3964–3967.

Marriage of Fellows.

To keep good teachers at Oxford University, the condition of celibacy must be abandoned, 3976.

JOWETT, Rev. B.—cont.

Mathematics.

Colleges at Oxford can provide good elementary mathematical instruction, 3890.

No instance of a distinguished mathematical student remaining long at Oxford University without a scholarship or fellowship, 3891.

Oxford students may pass in classics, without mathematics, at moderations, not at responsions; none can take a degree without some mathematics, 3912, 3913.

Science should be added to the mathematics essential for a degree at Oxford University, 3914–3916.

Matriculation.

Objection to preliminary examination on entrance to Oxford University, 3901.

Medicine.

Medical students at Oxford University might be admitted to honours, scholarships, and free education; and obtain degrees, at any time, on passing present examination, 3897–3902, 3936–3938.

Oxford medical students might alternate education in the University with hospital study in London or Edinburgh, 3964–3967.

New College (Oxford).

Combination of Balliol and New Colleges for lecture purposes, 3953.

Original Research.

Oxford University should be a place of scientific research, as well as of scientific teaching, 3977, 3978.

Oxford University.

Great change in system of education at Oxford University during the last 20 years, 3890.

Colleges at Oxford; did well in the past; combination essential, for pass-men, as well as for honours' purposes; revenues amount to three fourths of whole University; these should be used to promote science; colleges act independently; parliamentary aid essential to re-distribute endowments, 3890, 3893, 3953–3963.

Fellowships at Oxford; do great good; should not be infringed upon; collegiate funds might be applied to University without affecting fellowships; distinguished science students obtain fellowships or scholarships, 3890, 3891, 3903, 3962, 3963, 3975.

Scholarships at Oxford; more scholarships than fellowships desirable; number not few when compared with science students; physical science scholarships should be attached to University; few students qualified to take science scholarships, 3890–3903, 3927, 3928, 3962, 3963, 3968, 3969.

Students at Oxford; distinguished science students obtain fellowships, &c.; tendency of students to literature rather than science; few physical science students; teaching of students should be connected with the professions; study of Greek in schools would not interfere with students' science preparation for Oxford University, 3891–3897, 3903–3907, 3936–3938, 3970, 3972.

Laboratory and science teaching at Balliol College, Oxford, formerly; now given up, 3892.

Excellent provision of buildings and apparatus for science purposes at Oxford University; more than 100,000*l.* devoted to this purpose during the last 12 years, 3896, 3965.

Examinations at Oxford; present examinations should be maintained; objection to entrance examination; physical science and modern history should be added to moderations; to the mathematics essential for degree examination, science should be added, 3897–3902, 3910–3916.

Degrees at Oxford; present requirements should be maintained; candidates should have had both literary and scientific training; governing power should not be given until requirements of classical degree have been fulfilled; Greek should be essential; amount of science required should be small and exact, not general, 3897–3917, 3919, 3920, 3924–3927, 3936–3942, 3973, 3974.

Preponderance of law and history candidates over those for science at Oxford; teaching of history should be on a level with science, 3897, 3907, 3916.

There is no impediment to physical science teaching at Oxford; education in the University might alternate with hospital study in London or Edinburgh, 3964–3967.

More Oxford fellows should be employed in University teaching; the condition of celibacy must be abandoned, 3976.

Oxford should be a place of scientific research, as well as of scientific teaching, 3977, 3978.

Jowett, Rev. B.—cont.

Parliament.
- Parliamentary interference essential to tax colleges at Oxford for science purposes; many colleges would promote science of their own accord in time, 3958–3963.

Physics.
- No instance of a person, distinguished in physics, remaining long at Oxford University without a scholarship or fellowship, 3891, 3903.

Practical Instruction.
- Oxford education might easily be alternated with hospital study in London or Edinburgh, 3964–3967.

Professors.
- Professorial system of University teaching was revived when honours' system was instituted at Oxford University, 3890.
- Importance of Oxford fellowships, in respect to supply of University teachers, 3975.
- To keep teachers at Oxford, the condition of celibacy must be abandoned, 3976.

Scholarships. See *Fellowships and Scholarships.*

Schools.
- Study of Greek should be continued in the principal public schools; all boys not being required to learn it, 3971, 3972.

Science.
- Colleges at Oxford might promote science by combination, and use of their revenues; science should be connected with the professions, 3890, 3897.
- Literature, not science, is the attractive element in universities; literature is adapted to the many—science to the few; neither should be pursued exclusively; fellowships for science should not be given to those destitute of literature, 3897, 3904–3907, 3917, 3943–3947.
- Teaching of science is comparatively rare; before requiring science from persons, the means of their obtaining it must be provided, 3923.
- Cabinet ministers should possess knowledge of science; but Latin and Greek men would be better than chemists, 3948–3952.
- Study of Greek in public schools would not interfere with science students' preparation for universities, 3972.
- Science teaching does not succeed without scientific research, 3977.
- See *Degrees. Fellowships. Oxford University, &c.*

Scotland.
- In the Scottish universities, literature, not science, is the attractive element, 3897.

Students.
- Only one college at Oxford University contains more than 200 students; four or five only contain over 100, 3890.
- Until students are created, it is useless to set apart physical science scholarships and fellowships at Oxford, 3890.
- Physical science scholarships at Oxford are not few, when compared with number of science students; few students are qualified to take them, 3891, 3894.
- Balliol College students work at physical science in the museum, 3892.
- More science students at Oxford University now than 20 years ago; not more than there were five or six years ago, 3895.
- Honours' students at Oxford do not increase; to promote science, professional students must be drawn from, 3897.
- Medical and engineering students might be admitted to honours, scholarships (not fellowships), and free education, at Oxford; they might obtain degrees, at any time, on passing the present examination; they should not be examined on entrance, 3897–3902, 3936–3938.
- Literature more attractive than science to students in universities; preponderance of history candidates over those for science at Oxford; science fellowships should not be given to students destitute of literature, 3897, 3904–3907, 3913–3917.
- Oxford students pass moderations at end of first year and a half; after which, for a degree, they need not study classics further, 3910–3913, 3919, 3920.
- General (gradually narrowing into professional) education should be pursued by Oxford University students up to 21 or 22 years of age; the teaching is wanting in direct connexion with their future professions, 3918, 3970.
- The combination of colleges now for honours' purposes must be applied to pass-men as well, 3954.
- Oxford medical students might alternate University education with hospital study in London or Edinburgh, 3964–3967.

Jowett, Rev. B.—*Students*—cont.
- Advantageous to students to reside in colleges; science scholarships at Oxford should be attached to University, but students should have option of belonging to any college, 3968, 3969.
- Study of Greek in public schools would not interfere with students' science preparation for Oxford, 3972.
- Advantage of Oxford fellowships, in passing students through the University into professions, 3975.

LIGHTFOOT, Rev. JOHN PRIDEAUX, D.D. (Index of his Evidence.)

Accommodation for Science Purposes.
- Proposed taxation of undergraduates at Oxford University, for building examination schools, 4080.

Assistant Professors, Demonstrators, and Teachers.
- Colleges at Oxford would be more likely to supplement museum by supplying demonstrators, than by appointing college lecturers, 3995.
- Towards assistant professors, the University of Oxford might grant assistance; if not, the colleges might aid, 4036, 4037, 4080.
- Pay of Oxford mathematical and classical teachers is not sufficient to retain them in the University, 4038, 4077.
- Assistant professors at Oxford might have duty both to college and professors, if there were union of colleges, 4074.
- Assistant professors should be appointed at Oxford University, to enable professors to devote themselves to research, 4075, 4076.

Balliol College (Oxford).
- Union of University, Balliol, Merton, and Exeter Colleges, for mathematical teaching, 4003, 4004.

Cambridge University.
- Cambridge University students invited to compete for scholarships in Exeter College, Oxford; they have competed for fellowships, 4089.
- Scholarships offered by Trinity College, Cambridge, for which Oxford men may compete, 4089.

Children.
- Imperfect training of boys in schools; more general study would reveal aptitude; boys taking to science would continue it in the University, 4604–4608.

Degrees.
- Science should not be a *sine quâ non* for Oxford degrees, 4005.
- Degree obtained in one school preferable to a pass through two schools; enlarged knowledge in one subject should be deemed sufficient, 4005, 4084.
- Mathematics essential for Oxford degrees; pass mathematics are, algebra, first part of Colenso, or first six books of Euclid, 4006–4012.
- Double study of literature and science at Oxford University would deprive many students of degrees, 4015, 4023.
- Degrees in science at Oxford should not be taken by those destitute of literature, 4019, 4020.
- Cambridge and Oxford B.A. degrees imply mental culture; physical science might be desirable, if calibre of students were equal to it, 4023.
- Exeter College fellowships are usually gained by men standing between the B.A. and M.A. degree, 4058.
- Long reading for examination, after taking bachelor's degree, rather beneficial than not, 4059–4063.
- Difficulties of pass degree examinations at Oxford University, 4084.
- Failures in taking Oxford degrees, which the additional labour of attending natural science lectures would increase, 4086.

Education.
- General education has been the object of Oxford University; pressure from without is making it more special, 4013.
- The standard of school education is improving, 4028.

Election to Fellowships. See *Fellowships.*

Endowments.
- Oxford University could not endow new professorships without taxing its members, which would be objectionable, 4080.

Euclid. See *Mathematics.*

Examinations.
- A low honour obtained by examination in one school is better than a pass through two schools; enlarged knowledge in one subject should be sufficient, 4005, 4084.

LIGHTFOOT, Rev. J. P.—*Examinations*—cont.

After moderations at Oxford, students may optionally study classics, science, &c.; they may go out in any one school by taking an honour, otherwise they must go out in two schools, 4006-4012.

After responsions at Oxford, pass-men might discontinue Latin prose; Greek should not be abandoned, 4018.

Objections to earlier classical examinations at Oxford University, 4018.

Examinations at Exeter College, Oxford; matriculation examination is framed to encourage divers studies in schools; its standard could not be raised, except gradually; in scholarship examinations, natural science was formerly included, but is discontinued; election to fellowships is by competitive examinations, 4024-4027, 4033, 4057.

Matriculation examinations at Oxford University are carried on by special colleges—responsions by University, 4025.

In Oxford matriculation examination of pupils from schools, science should be optional; classics and mathematics are more desirable subjects, 4031-4033.

Difficulties of pass degree examinations at Oxford, 4084.

Exeter College (*Oxford*).

Fellows of Exeter College; 15 in number; 8 in residence; of 9, elected since ordinances, 3 have taken highest honours in mathematics; a fine threatened for non-residence of fellows; reduction of income of non-resident fellows will be essential, 3980-3988, 4042-4054.

Students at Exeter College; 5 studying science, and 1 at museum; fees of students not more than essential for government of college, 3980-3985, 4078.

Fellowships at Exeter College; none obtained by natural science knowledge; more fellowships desirable; college can suppress fellowships; wants of college are considered in fellowship elections; tenure of fellowships are subject to condition of celibacy; lay fellowships; value of fellowships about 240*l.*, 3986, 3987, 3991, 3992, 4039-4063, 4077.

Promotion of science at Exeter College; by lecturers formerly; now by rewards of books, remittance of fees, &c., 3988, 3989.

Revenues and fees of Exeter College; part of science students' fees returned; college revenues could not be devoted to University scientific fund; revenues left by founders are applied to fellowships, scholarships, &c.; funds are under control of college, 3988, 3989, 3994, 3998-4001, 4034, 4035, 4077.

Exeter College does not labour under any disability with respect to furtherance of science, 3993.

List of lectures given at Exeter College; nearly 40 different courses, 4002, 4003.

Exeter College united with University, Balliol, and Merton for mathematical teaching, 4003, 4004.

Examinations at Exeter College; matriculation examination; failures of candidates; natural science formerly included in scholarship examinations, 4024-4027, 4033.

Scholarships at Exeter College; educational council willing to encourage science by scholarships; scholarships are offered to University at large; Cambridge men may compete, 4033, 4089.

Exhibitions. See *Fellowships and Scholarships.*

Fees.

Students' fees at Exeter College, Oxford; in part remitted, to encourage natural science, 3988, 3998-4001, 4072.

With a large number of science students at Oxford University, assistant professors might be aided by returned fees of students, 4036.

Most Oxford colleges might possibly spare a portion of their fees for science purposes, 4078.

Exeter College students' fees are not more than essential for government of college, 4078.

Fellowships and Scholarships.

At Exeter College, Oxford, there are 15 fellows, under the new ordinances; no fellowship obtained through science; of 9 mathematical fellows, 3 obtained highest honours in mathematics, and 1 only in science, 3982, 3986, 3987, 4042-4047.

To encourage science at Oxford University, more scholarships and fellowships should be given, 3991.

At Exeter College, of 22 scholarships, 6 are held by mathematicians; of 9 exhibitions, 3 are held by mathematicians; not one being given for physical science, 3991.

Two fellowships, for all subjects, offered by Exeter College; two science competitors only; awarded to classical candidates, 3992.

LIGHTFOOT, Rev. J. P.—*Fellowships, &c.*—cont.

Exeter College would willingly encourage science by occasional scholarships and fellowships; formerly introduced natural science in its scholarship examinations, 4033.

Colleges at Oxford, to apply their revenues to science teaching in the University, would have to reduce incomes of fellowships, 4038.

With present number of non-residents, the fellowships at Exeter College, Oxford, are not too many, 4039.

Exeter College has power to suppress fellowships, subject to assent of visitor; not likely to suppress any; no legislative power necessary, 4040, 4041.

Tenure of Exeter College fellowships; it is subject to condition of celibacy; curtailing freedom of tenure, or reducing income of non-resident fellows, will be essential, 4053, 4054, 4079.

Lay fellowships at Exeter College; can be retained for 15 years; 10 years' educational work in the college entitles to a lay fellowship for life, 4053.

Non-residence of fellows at Exeter College; fines for non-residence threatened, but never imposed; this should be settled by college statute, 4050-4052.

240*l.* is the average value of Exeter College fellowships; residents having also 2*s.* a day, and rooms rent free, 4055, 4056.

Election to fellowships at Oxford University; no preference is given by colleges to their members; election at Exeter College is by competitive examination; wants of college as to lecturers being considered; 4057-4059.

Exeter College fellowships are generally gained by men standing between the B.A. and M.A. degree, 4058-4063.

Many Oxford men with highest honours are unable to obtain a fellowship, 4066.

With increase of qualified students at Oxford University, natural science fellowships would probably increase, 4069.

Fellowship revenue must not be confounded with tuition money, 4077.

Oxford fellowships may be for reward for past work, or for securing rest for future study; they are not necessarily connected with any teaching duty, 4077.

Objection to offering scholarships for science at Oxford, as diverting students from mathematics and classics, 4082.

To take away Oxford University fellowships would be to remove a beneficial stimulus to students, 4087.

Scholarships at Exeter College, Oxford, and Trinity College, Cambridge; open to men of either university, 4089.

Grants for Science Purposes.

Exeter College, Oxford, is not at liberty to make grants to University fund for science; has no funds available for science except the students' contributions, 3994, 3998-4001, 4077, 4078.

For establishing assistant professors at Oxford, the University might grant assistance, or the colleges might aid, 4036, 4037.

Greek.

Objection to giving up study of Greek at Oxford University, 4018.

Honours.

Of nine mathematical fellows, elected since University Commission by Exeter College, Oxford, three have gained highest honours in mathematics, and one only in physical science, 3987.

Natural science encouraged at Exeter College by rewards of books to those taking honours in science, 3988.

Natural science schools at Oxford have become almost entirely honours' schools; this is to be lamented, 3988.

If further assistance is given to honours' candidates, it should be given through the professors, 3989.

A low honour in one school more valuable than a pass through two schools, 4005.

After moderations, Oxford students may take classics, science, &c., and pass out in one school, on taking an honour; otherwise, they must go out in two schools, 4007-4010.

Honour men at Oxford would be unequal to double study of literature and science, 4016, 4023, 4024.

Many Oxford men, with highest honours, are unable to obtain a fellowship, 4066.

Oxford University teaching, while preparing men for honours, would include inferior students, 4073.

Fewer pass-men at Oxford now, but as many who take honours, 4088.

See *Degrees.*

LIGHTFOOT, Rev. J. P.—cont.

Income.

Revenues of Exeter College, Oxford, are applied to support of fellows, scholarships, &c.; could not be diverted without consent of whole body, or without parliamentary aid, 4031, 4035, 4077.

Oxford University has only a small surplus of income at disposal; unsafe to be without a surplus, 4037, 4081.

Colleges at Oxford, to apply their revenues to University science purposes, would have to lessen income of fellows, 4038.

Reduction of income of non-resident Exeter College fellows will be essential, 4054.

Exeter College fellowships are worth about 240*l.*; residents having 2*s.* a day, and rooms rent free, 4055, 4056.

Latin.

Latin prose composition at Oxford; difficult for many students; might be abandoned after responsions; its decline shown in examinations, 4018, 4027.

Lay Fellowships. See *Fellowships.*

Lectures and Lecturers.

Natural science lectures formerly given at Exeter College, Oxford; present courses of lectures; nearly 40 in number, 3988, 3989, 4001–4004.

Union of University, Balliol, Merton, and Exeter Colleges, for lecture purposes, 4003, 4004.

College lecturers on science would be desirable at Oxford if pass students were as numerous as formerly, 3989.

Control over lectures in natural science should be in the hands of professors, 3996, 4072.

Oxford professors, for purposes of research, should be relieved from giving many lectures, 4075, 4076.

Literature.

Two fellowships, for all subjects, offered by Exeter College, Oxford, were gained by classical students; only two science competitors, 3992.

List of lectures on literature, &c. given at Exeter College, Oxford, 4001.

Natural science students at Exeter College would draw off those from the classical lectures, 4002.

Classical degrees at Oxford; only a small amount of mathematics or logic required; after moderations, classics alone may be taken; for passing out, classics is essential, 4006–4010.

Double study of literature and science could not be undertaken by Oxford students, 4015, 4023.

Latin prose might be dispensed with after responsions by pass-men at Oxford; decline in Latin prose at Oxford; objection to giving up Greek, 4018, 4027.

Objection to earlier classical examinations at Oxford University, 4018.

Degrees in science at Oxford should not be taken by those destitute of literature, 4019, 4020.

Classics more desirable than science in matriculation examination at Oxford, 4031–4033.

Interest of Oxford colleges to have good classical classes; introduction of science students would diminish these, 4069, 4070.

Classical tutors at Oxford are not too well paid, 4077.

Objection to offering science scholarships at Oxford, as diverting students from classics, 4082.

Logic.

For classical degree at Oxford, logic may be taken, 4007.

Marriage.

Tenure of fellowships at Exeter College, Oxford, is subject to condition of celibacy, 4053.

Mathematics.

Of nine mathematical fellows at Exeter College, Oxford, elected since Commission, three have obtained highest honours in mathematics, and only one in physical science, 3986, 3987.

Mathematics is essential for Oxford degrees; pass mathematics for final schools are, algebra, first part of Colenso, or first six books of Euclid, 4006–4012.

Mathematics more desirable than natural science in matriculation examination at Oxford, 4033.

Interest of Oxford colleges to have good mathematical classes; introduction of natural science students would diminish these, 4069, 4070.

Objection to offering science scholarships at Oxford, as diverting students from mathematics, 4082.

Matriculation.

Matriculation examination at Oxford; carried on by colleges, not University; numerous rejections; standard could not be raised, except gradually; for pupils from schools, science should be optional; classics and mathematics more desirable, 4024–4027, 4031–4033.

LIGHTFOOT, Rev. J. P.—cont.

Merton College (Oxford).

Union of Merton, Balliol, Exeter, and University Colleges, for mathematical teaching, 4003, 4004.

Original Research.

For purposes of research, Oxford professors should be relieved in teaching, 4075, 4076.

Oxford University.

Regret that the schools at Oxford University have become almost entirely honour schools, 3988.

Colleges at Oxford; union of colleges, and of colleges with University, for teaching purposes, desirable; colleges more likely to provide demonstrators than college lecturers; all colleges have matriculation examination; revenues; several can suppress fellowships, 3989, 3995–3997, 4004, 4026, 4027, 4034–4041, 4058, 4069–4074, 4080.

Oxford professors; assistance to honours' men at Oxford should be through professors; science professors should control the whole work under them; for research purposes, professors should be relieved in lecturing, 3989, 3996, 4075, 4076.

Oxford fellowships and scholarships; more wanted, to encourage science; emoluments of non-resident fellowships will have to be reduced; election not confined by colleges to their members; men with highest honours unable to obtain a fellowship; science fellowships might increase with qualified students; fellowships are not necessarily connected with teaching; objection to taking away fellowships, 3991, 3992, 4054–4063, 4066, 4069, 4077, 4079, 4087, 4089.

Assistant professors at Oxford; University or colleges might aid in supplying demonstrators, who would be necessary to enable professors to pursue research; they might have duty both to college and to professors, 3995, 4036–4038, 4071–4076.

Oxford examinations; after moderations, classics, science, &c. may be taken; after responsions, pass-men might discontinue Latin prose, but not Greek; objection to earlier classical examination; matriculation examinations are carried on by special colleges, responsions by University; in matriculation examinations science should be optional, but classics and mathematics essential; in degree examinations enlarged knowledge in one subject should be sufficient, 4005–4012, 4018, 4024–4027, 4031–4033, 4057, 4084.

Oxford degrees; science should not be a *sine quâ non;* mathematics essential; literature and science combined would deprive students of degrees; those destitute of literature should not be granted degrees; Exeter College fellowships are gained by men standing between B.A. and M.A. degree, 4005–4012, 4015, 4019, 4020, 4023, 4058–4063, 4084.

Oxford students; few now in physical science schools; deficiency of students in Latin prose; bad training of students entering University; taxation of students; failures of students in taking degrees; fellowships a stimulus to students, 3984–4036, 4065–4069, 4080, 4085–4089.

The standard of schools must by degrees depend on requirements of University, 4029, 4065–4068.

Oxford University has now a very small surplus of annual income at disposal, 4036, 4037.

Development of study at Oxford is impeded by want of preparation in students entering, 4064.

With more prizes at Oxford, natural science will gradually be more studied, 4065.

Sudden change in favour of science at Oxford would be difficult; there is an increasing disposition to give prizes for science, 4069.

The professional teaching of the University of Oxford, while preparing men for honours, would include inferior students, 4073.

Classical tutors at Oxford are not too well paid, 4077.

Oxford could not endow new professorships without taxing its members, 4080.

See *Exeter College (Oxford)*

Oxford University Commission.

Compromise effected between Commission and Exeter College, Oxford, respecting lay fellowships, 4053.

Parliament.

Exeter College, Oxford, and some others, can suppress fellowships, without aid of Parliament, 4040, 4041.

Collegiate revenues could not be diverted from the fellows without parliamentary aid, 4077.

Pattison, Mr.

Objection to Mr. Pattison's opinion respecting the small value of Oxford fellowships, 4087.

LIGHTFOOT, Rev. J. P.—cont.

Professors.

If further assistance be provided for honours' candidates at Oxford University, it should be given through the professors, 3989.

Oxford science professors should have the whole work under their control, 3996, 4072.

For purposes of research at Oxford, professors should be relieved from too much lecturing, 4075, 4076.

Professorships.

Oxford University could not endow new professorships without taxing its members, which would be objectionable, 4080.

Revenues. See *Income.*

Salaries.

The pay of mathematical and classical teachers at Oxford University is not sufficient to retain them; tuition money not to be confounded with fellowship revenue, 4038, 4077.

Scholarships. See *Fellowships and Scholarships.*

Schools.

Encouragement of divers studies in schools by matriculation paper of Exeter College, Oxford, 4024–4027.

Standard of school education is improving; by degrees it must depend upon university requirements, 4028–4030.

In some schools, attention shown to best pupils appears to be at expense of inferior ones, 4028.

Pupils from schools, in university matriculation examinations, might voluntarily show knowledge of science; but classics and mathematics are more desirable subjects, 4031–4033.

Bad training in schools an impediment to study at Oxford University; change in University would presuppose change in schools, 4064–4068.

Science.

Science should not as yet be considered a *sine quâ non* for Oxford University degrees, 4005.

Double study of literature and science not adapted to University students, 4015, 4023.

University science degrees, without any tincture of literature, would be a misfortune, 4019.

Aptitude for science, developed in schools, would be continued in the University, 4069.

To promote scientific research, professors should be relieved from much lecturing, 4075, 4076.

Were classics and mathematics on an equality with science at Oxford, the gain to science by the acquisition of a scholar would be greater than the loss to mathematics and classics, 4083.

See *Exeter College (Oxford). Oxford University.*

Students.

At Exeter College, Oxford, there are 160 undergraduates in residence; five only studying science; one working in museum, 3981–3985.

Science is encouraged at Exeter College by rewards to students taking science honours, and remission of fees; one or two students have succeeded in science; one has obtained a fellowship, 3988, 3991, 3998–4001.

Students in Oxford physical science schools; fewer passmen now than formerly, but as many for honours, 3988, 4033, 4088.

If further aid be given to honours' candidates at Oxford, it should be through professors, 3989.

Better for students to be disciplined in one subject, than to get a degree through a smattering of many, 4005.

Oxford students, after moderations, may study classics, science, &c.; they may go out in any one school by taking an honour; otherwise they must go out in two schools, 4006–4012.

Double study of literature and science not practicable for Oxford students; honour men would have to sacrifice special study, 4015, 4016, 4023, 4024.

Rejection of candidates for Exeter College, Oxford, 4026.

Failure of Oxford students in respect to Latin prose, 4027.

Classics and mathematics more desirable than natural science for entrance examinations of Oxford students, 4031–4033.

Assistant professors at Oxford might be aided by returned tuition money, if there were a large number of science students, 4056.

Study at Oxford University impeded by bad training of students who enter, 4065–4068.

Increase of qualified students at Oxford would probably increase natural science fellowships, 4069.

Interest of colleges at Oxford to have good classical and mathematical classes; introduction of natural science students would diminish these, 4069, 4070.

LIGHTFOOT, Rev. J. P.—*Students*—cont.

Proposed taxation of Oxford undergraduates for building purposes; increase of payments always objectionable, 4080.

Oxford students have the option of studying natural science now, 4085.

For every student who takes a pass degree at Oxford there is one failure, 4086.

Beneficial stimulus afforded to students by fellowships, which are considered a great prize, 4087.

Cambridge students invited to compete for Oxford scholarships, and Oxford men for Cambridge scholarships, 4089.

Temple, Dr.

Failure of one of Dr. Temple's pupils in matriculation examination at Oxford, cited as a good example, 4029.

Trinity College (Cambridge).

Scholarships offered by Trinity College, Cambridge, for which Oxford men may compete, 4089.

Tutors. See *Assistant Professors, &c.*

University College (Oxford).

Union of University, Balliol, Merton, and Exeter Colleges, for mathematical teaching, 4003, 4004.

MASKELYNE, PROFESSOR NEVIL S., M.A. (Index of his Evidence.)

Age of Students.

Undergraduates at 19 or 20 years of age could not have mastered the fundamental branches of education, 4137.

Assistant Professors, &c.

Holders of fellowships and scholarships at Oxford University should assist the professors in teaching, 4112.

Botany.

At Oxford University, botany should be encouraged by fellowships, &c.; but honours in botany should be given only to those who had mastered the foundations of science, 4108, 4111, 4129–4143.

Botany is not adapted for a school of examination, 4119–4121.

Without a knowledge of vegetable physiology, a botanist would be imperfectly educated, 4132.

Buckland, Dr.

Good work done by Dr. Buckland, while professor of mineralogy at Oxford University, 4113.

Cambridge University.

Teaching of mineralogy at Cambridge University; important work done by Professor Miller and Dr. Whewell, 4103, 4113.

Chemistry.

Crystallography, hydrostatics, heat, and magnetism are essential to the education of the chemist, 4100, 4132.

University honours in chemistry should not be taken without crystallography, 4105–4107.

Mineralogy might be taught as a classificatory department of inorganic chemistry, 4116–4118.

Chemistry is one special subject of Oxford University science school; without this, honours should not be granted in a classificatory science, of which chemistry is the foundation, 4122, 4132–4143.

Crystallography.

Crystallography is taught at Oxford University as an alternate course with mineralogy; five good students attended last course, 4091–4096.

Difficulty of teaching crystallography at Oxford, through inefficient mathematical knowledge of students, 4097–4099.

Crystallography should be an essential part of the education of physicists, chemists, and geologists, 4100, 4132.

Only a moderate amount of mathematics is essential in the study of crystallography, 4101, 4102.

In England, crystallography is at the lowest ebb; more studied on the continent, 4103–4105.

At universities, crystallography should be connected with teaching in schools; without it, honours should not be taken in chemistry, &c., 4106, 4107, 4113.

Special Oxford scholarships and fellowships for crystallography not essential, 4108.

See *Mineralogy.*

Degrees. See *Honours.*

Education.

English people do not feel the necessity of scientific education, 4105.

England.

Low state of crystallographic knowledge in England; indifference to science generally, 4103–4105.

Maskelyne, Professor N. S.—cont.

Examinations.
- Classificatory subjects are not adapted to schools of examination, 4119–4121.
- Oxford fellowships, &c., for classificatory sciences, should be given after a general and a special examination, 4129–4131.

Fellowships and Scholarships.
- Special Oxford scholarships and fellowships for crystallography not essential, 4108.
- Many Oxford colleges have ample funds for providing fellowship and scholarship rewards, 4109.
- Classificatory sciences should be encouraged at Oxford by special fellowships and scholarships to candidates who have taken other subjects; might be granted for three years, with extension where holder assisted professors, &c., 4108–4121, 4129–4141.
- Vinerian law fellowships at Oxford are conferred as extra rewards, 4135.

Geology.
- Geology is only imperfectly pursued at Oxford University; it should be encouraged by scholarships, &c., 4096, 4108.
- Crystallography an essential part of the education of a geologist, 4100, 4105.
- Importance of mineralogy as a key to geology, 4117.
- At Oxford University, honours in geology should be granted only to those who had mastered the foundations of science, 4132–4143.

Geometry. See *Mathematics.*

Germany.
- Crystallography is much more studied in Germany than in England, 4104.

Greek.
- Greek a nobler language than Latin; at Oxford, Latin might be dispensed with in preference, 4128.

Honours.
- University honours in heat or chemistry should not be taken without a knowledge of crystallography, 4107.
- Oxford students can take honours in the natural science school without mathematics, 4123–4125.
- A science line, in which honours might be taken, is essential at Oxford University, 4126.
- Classificatory sciences at Oxford should be extra honours' subjects, and granted only where fundamental branches of science have been mastered, 4129–4143.

Hydrostatics.
- A chemist without a knowledge of hydrostatics would be imperfectly educated, 4132.

Income.
- Many Oxford colleges have ample funds for founding scholarship and fellowship rewards, 4109.

Kidd, Dr.
- Good work done by Dr. Kidd, while professor of mineralogy at Oxford University, 4112.

Literature.
- Oxford science candidates for honours should show literary attainment; they should know Latin or Greek before entering University, 4127, 4128.

Magdalen College (Oxford).
- Chair of mineralogy to be founded by Magdalen College; postponed at present, 4114, 4115.

Mathematics.
- Difficulty of teaching crystallography at Oxford, through deficiency of students in mathematics, 4097–4099.
- But little mathematics is required for the study of crystallography; trigonometry and geometry sufficient, 4101, 4102.
- The basis of a scientific education lies in mathematical training; this is not sufficiently appreciated, 4105.
- A minimum of mathematics should be demanded of every one entering Oxford University science school, 4122.
- Mathematical knowledge is essential even for physiologists, 4122.
- Honours can be taken in the natural science school at Oxford without mathematics; for classificatory sciences, a basis of mathematics should be essential to the granting of honours, 4123–4125, 4132–4143.

Miller, Professor.
- Beautiful system of crystallography founded by Professor Miller, of Cambridge, good work done by him while professor, 4103, 4113.

Mineralogy.
- Mineralogy taught at Oxford University as an alternate course with crystallography; three students attended last course, 4091–4096.

Maskelyne, Professor N. S.—*Mineralogy*—cont.
- Mineralogy is imperfectly pursued at Oxford University; it should be encouraged by scholarships, &c., 4096, 4108, 4141.
- Were crystallography an essential part of university scientific education, professorships of mineralogy would be of importance, 4113.
- Chair of mineralogy to be founded by Magdalen College, Oxford; matter postponed at present, 4114, 4115.
- Importance of mineralogy in relation to chemistry, geology, and mining, 4116–4118.
- Mineralogy, but for its relation to mining industry, would have been absorbed into inorganic chemistry, 4118.
- Mineralogy is not adapted for a school of examination, 4119–4121.
- Oxford University should not grant honours in mineralogy, except to those who have mastered the fundamental branches of science, 4129–4143.
  - See *Crystallography.*

Mining.
- But for its relation to mining industry, mineralogy would have been absorbed into inorganic chemistry, 4118.

Oxford University.
- Study of mineralogy and crystallography at Oxford, 4090–4143.
- Oxford students; five attending crystallography, three mineralogy, last courses; many want mathematical knowledge; should have a basis of mathematics before entering, 4093–4099, 4122–4128.
- Mineralogy and geology are imperfectly pursued at Oxford; crystallography should be connected with teaching; mineralogy has great claim to recognition 4096, 4106, 4117.
- Honours at Oxford can be taken in the natural science school without mathematics; there should be a science line in which honours could be taken, 4107, 4123–4143.
- Oxford fellowships and scholarships; should be given to encourage study of classificatory sciences; might be granted for three years, with extension where deserved; Vinerian law fellowships, 4108–4112, 4119–4121, 4129–4141.
- Oxford colleges; many have ample funds to provide rewards for science; decisions of University Commission unfortunately left to colleges themselves, 4109, 4114.
- Good work done at Oxford by professors of mineralogy, 4113.
- Chair of mineralogy proposed to be endowed by Magdalen College, 4114, 4115.
- Mineralogy, botany, geology, and zoology are not adapted to the University schools; should be rewarded only where fundamental branches of scientific study have been mastered, 4119, 4120, 4129–4143.
- Oxford should not pronounce a man scientifically educated merely upon a knowledge of a classificatory science, 4121.
- Physics, physiology, and chemistry are embraced in Oxford University science school; preliminary mathematical knowledge should be exacted, 4122.
- Advantage of retaining Greek at Oxford, 4128.
- Sanscrit is much studied at Oxford; it is not part of the general course, but might be, 4135, 4136.

Oxford University Commission.
- Decisions of Commission were unfortunately left to colleges themselves to carry out, 4114, 4115.

Physics.
- To the physicist, crystallography should be an essential part of education; honours in physics at universities should not be taken without crystallography, 4100, 4105–4107.
- Physics (comprising all branches of natural philosophy) is one special subject of Oxford University science school; without this, honours should not be given for a classificatory science, 4122, 4132–4143.
- A chemist without a knowledge of heat, magnetism, &c., would be imperfectly educated, 4132.

Physiology.
- Physiology is one special subject of Oxford University science school; honours in zoology should not be granted where the fundamental subjects of physiology, &c. have not been attained, 4122, 4132–4143.
- Mathematical knowledge is essential even for physiologists, 4122.
- A botanist without a knowledge of vegetable physiology would be imperfectly educated, 4132.
  - See *Zoology.*

Maskelyne, Professor N. S.—cont.

Professors.

Holders of Oxford fellowships and scholarships should assist the professors, 4112.

Professorships.

Were crystallography an essential part of university scientific training, professorships of mineralogy would be important, 4113.

Sanscrit.

Sanscrit is much studied at Oxford; not part of general course, but might be, 4135, 4136.

Scholarships. See *Fellowships and Scholarships.*

Schools.

Classificatory subjects are not adapted to schools of examination, 4119–4121.

Physics, physiology, and chemistry are the proper subjects for a science school; a minimum of mathematical knowledge should be essential for entrance, 4122.

Good preparation in public schools will raise standard of university science schools, 4127.

Science.

Mineralogy and geology are only imperfectly pursued at Oxford University, 4096.

Crystallography at low ebb in this country; more studied in Germany; at universities, it should be connected with teaching in schools, 4103, 4104, 4106.

English people do not feel the necessity of scientific education, 4105.

Upon the knowledge of a classificatory science only, Oxford University should not pronounce a man scientifically educated, 4121.

Science Schools. See *Schools.*

Students.

Oxford students of crystallography and mineralogy; many students are deficient in mathematics, and have been taught separately, 4093–4099.

Mathematics should be demanded of every student entering Oxford University science school, 4122.

At Oxford University, students can take honours without training in mathematics, 4123–4125.

Students should be able to take honours in a science line at Oxford University; literary attainment should be required, 4126, 4127.

Oxford students should know Greek or Latin before entering university, 4128.

Trigonometry. See *Mathematics.*

Universities.

At universities, crystallography should be connected with teaching of schools, 4106, 4107, 1113.

See *Oxford University.*

Vinerian Law Fellowships. See *Fellowships.*

Whewell, Dr.

Good work done by Dr. Whewell, while professor of mineralogy at Cambridge University, 4113.

Zoology.

At Oxford University, zoology should be encouraged by scholarships, &c., 4108.

Zoology is not adapted for a school of examination, 4119–4121.

Oxford University should grant honours in zoology only to those who have studied the fundamental branches of that science, 4132–4143.

See *Physiology.*

LIDDELL, Very Rev. HENRY GEORGE, D.D. (Index of his Evidence.)

Accommodation for Science Purposes.

Noble institution for advanced physical teaching at Oxford University, erected from profits of Lord Clarendon's History, 4158.

Anatomy.

Lee's reader in anatomy in Christ Church College, Oxford; salary 300*l.*, with grants; acts in concert with university professors; is stationed in museum; his teaching is preparatory to professional study, 4149, 4152–4156, 4165, 4191.

Anatomy is one subject of examination for Christ Church College studentships, 4214.

Apparatus for Science Purposes.

Students of Christ Church College, Oxford, attend the Hyde Institute for the physical apparatus there, 4158, 4165.

Assistant Professors, Demonstrators, and Teachers.

Teachers at Christ Church College, Oxford; difficulty of getting them, 4150, 4151, 4180.

Christ Church College reader in physics is also demonstrator at Hyde Institute, 4153, 4154.

Liddell, Very Rev. H. G.—cont.

Chemistry.

Lee's reader in chemistry in Christ Church College, Oxford; salary 300*l.*, with grants; does not lecture at museum as Lee's reader, 4149, 4152–4156.

Christ Church College has a chemical laboratory; students need not go to museum for practical chemistry, 4157, 4165.

Chemistry is one subject of examination for Christ Church College studentships, 4214.

Christ Church College (Oxford).

Dr. Lee's foundation at Christ Church College, Oxford; about 2,600*l.* a year; more than half applied to science; all may be ultimately available, 4144–4148, 4192, 4193.

Readers in anatomy, chemistry, and physics at Christ Church; salaries 300*l.*, with grants; act with university professors; mathematical teachers paid from same source, 4149–4156, 4191.

Lectures by Christ Church College readers; partly given at Hyde Institute; open to all university; few attend; general lectures more elementary than in museum, 4154–4165.

Christ Church College students; all go to museum; few compete for science studentships; many candidates are incompetent; senior students are mostly resident in college, and employed in college work, 4154, 4158–4165, 4170–4182.

There is a chemical, but not a physical laboratory, at Christ Church College, Oxford, 4157, 4158.

Oxford University collections are mostly a loan from Christ Church College, 4155, 4156.

Studentships at Christ Church College; 30 junior, 5 in mathematics, 5 in physical science; candidates few; senior studentships not awarded for science; not more studentships than required, 4166–4180, 4187, 4214.

Clarendon, Lord.

Hyde Institute erected out of the profits of Lord Clarendon's History, 4158.

See *Hyde Institute.*

Corpus Christi College (Oxford).

Corpus College, Oxford, of its own free will, has lately endowed a professorship in law, 4189.

Degrees.

Literary culture should be shown by all taking degrees in science at Oxford University, 4204.

Admission of Oxford science students to scholarships, but not to fellowships without taking a degree, could not be a permanent system, 4205.

See *Honours.*

Education.

Education in schools must be altered to increase science candidates at Oxford University, 4175.

Scientific, without literary culture, would not be satisfactory education, 4220.

Literary education at Oxford University is not altogether without science, 4221.

Endowments.

Dr. Lee's endowment at Christ Church College, Oxford; more than half applied to science; all may ultimately be available, 4144–4148, 4192, 4193.

Endowment of future professorships at Oxford University must come from the colleges, 4208, 4209.

Examinations.

In elections to 1 in every 3 open junior studentships at Christ Church College, Oxford, mathematics and physical science are alternately subjects of examination; anatomy, chemistry, or physics required, 4166, 4168, 4214.

Examination of Oxford pass-men is more severe than formerly; more mathematics involved, 4194.

Fellowships.

College fellowships at Oxford University; some might be retained as prizes, and be terminable in seven or ten years, 4188, 4189.

Admission of Oxford science students to scholarships, but not to fellowships without taking a degree, could not be a permanent system, 4205.

Oxford fellowships are more for literature than science; with more fellowships, there might be more scientific students, 4215–4217.

While university fellowships are given for one kind of education, schools will prepare with special reference to it, 4218.

See also *Scholarships.*

Honours.

Students attending Lee's readers' lectures at Christ Church College, Oxford, are all going out in honours, 4162.

LIDDELL, Very Rev. H. G.—*Honours*—cont.
Oxford honours' men should not be forced to take more than one subject; they can pursue their own line of study after a certain time; should show literary culture, but at any period, 4183, 4197–4199.

Hyde Institute.
Christ Church College, Oxford, reader in physics is also demonstrator in the Hyde Institute, 4153, 4154, 4158.
Oxford students of physics will always go to the Hyde Institute for the valuable apparatus there, 4165.

Income.
Lee's foundation at Christ Church College, Oxford, is about 2,600*l.*; more than half applied to science; the whole may ultimately be available, 4145–4148, 4192, 4193.
See *Salaries.*

Laboratories.
Christ Church College, Oxford, has a chemical, but not a physical laboratory, 4157, 4158, 4165.

Law.
Professorship in law lately founded and endowed by Corpus College, Oxford, 4189.

Lectures.
Lectures by Lee's readers at Christ Church College, Oxford; open to all university; attendance small; more elementary than in museum, 4154–4165, 4190.

Lee, Dr. See *Christ Church College (Oxford).*

Literature.
Where science is severely taught, students might prefer literature, 4176.
Oxford pass-men should exhibit literature and science; honours' men should show literary culture, but at any period, 4183–4186, 4195–4204.
Desirable that honours' men in classics at Oxford should show knowledge of science; but system not to be recommended at present, 4200–4204, 4222.
Literary culture should be required of all who pass the Oxford curriculum, 4203.
More Oxford fellowships are given for literature than for science, 4215–4217.
Scientific, without literary culture, would not be satisfactory education, 4220.
Literary education at Oxford University is not altogether without science, 4221.

Mathematics.
Mathematical teachers at Christ Church College, Oxford; paid partly from Dr. Lee's fund and partly from the tutorial fund, 4150, 4151.
Mathematics and physical science are alternate subjects for one in three studentships at Christ Church College, Oxford, 4168.
Examination of Oxford pass-men involves more mathematics than formerly, 4194.

Original Research.
Professors devoted to research should reside in Oxford University; one or two there now; many of the university professors have leisure for research, 4225, 4226.

Oxford University.
Christ Church College readers; act with university professors; physiology reader is stationed in university museum; lectures open to all university, 4152–4155, 4159, 4165.
Bulk of university collections belong to Christ Church College, and are deposited in museum, 4155, 4156.
Advanced instruction in physics, &c. given in the Hyde Institute; valuable apparatus there, 4153, 4158, 4165.
Oxford students; number in university increasing; pass-men should show literature and science; honours' men should exhibit literature, but at any period; classical honours' men might show knowledge of science, but not to be recommended at present, 4163, 4183–4186, 4197–4199, 4200–4204.
Alteration in schools essential to increase candidates for science prizes at Oxford, 4171, 4175.
To encourage science, present means of university might be enlarged; supply now is equal to demand, 4178.
Oxford fellowships; there should be some terminable in seven or ten years; objection to admission of science students to scholarships, &c., but not to fellowships without taking a pass-degree; more fellowships might create more science students, 4188, 4189, 4205, 4215–4217.
Many Oxford colleges are or will be able to contribute towards a university education; most have done so, 4189.
Oxford professorships; Corpus College has founded a professorship in law; endowment of future professorships must come from the colleges, 4189, 4208, 4209.

LIDDELL, Very Rev. H. G.—*Oxford University*—cont.
Examination of Oxford pass-men is more severe than formerly; it involves more mathematics, 4194.
Literature should be required of all who pass the Oxford curriculum; literary education of Oxford is not without science, 4198–4204, 4221.
Oxford professors; should be appointed as need arises; eminent men devoted to research should reside in university; many university teachers have leisure for research now, 4206, 4207, 4224–4226.
Oxford University should be a school for furnishing access to the means of combining practice with instruction, 4210, 4211.

Parliament.
Junior studentships for physical science awarded by Christ Church College, Oxford, under Act of Parliament, 4166.

Physics.
Lee's reader in physics at Christ Church College, Oxford; salary 300*l.*, with grants; acts in concert with university professors, 4149, 4152–4155.
No physical laboratory at Christ Church College; students go to Hyde Institute for the valuable apparatus, 4158, 4165.
Physics is one subject of examination for Christ Church College studentships, 4214.

Physiology.
The Christ Church College, Oxford, reader in physiology is stationed in the University Museum, 4155, 4165.
See *Anatomy.*

Practical Instruction.
Oxford University should be a school for furnishing access to the means of combining practice with instruction, 4210, 4211.
For practical instruction in chemistry, Christ Church College students need not go to University Museum, 4165.

Professors.
Readers in anatomy, chemistry, and physics at Christ Church College, Oxford; act with university professors; they are classed as students, 4149, 4152–4156, 4179.
Better to appoint Oxford professors as need arises; increase unnecessary at present, 4206, 4207.
Oxford University should have power to appoint professors devoted to special teaching, 4224.
Resident professors devoted to research desirable in Oxford University; one or two there now; many of the professors have leisure for research, 4225, 4226.

Professorships.
Corpus College, Oxford, has lately founded and endowed a professorship in law, 4189.
Endowment of future Oxford professorships must come from the colleges, 4208, 4209.

Readers. See under *Professors.*

Salaries.
Lee's readers in anatomy, chemistry, and physics at Christ Church College, Oxford, have 300*l.*, with grants from tutorial fund; mathematical teachers are paid from same source, 4149, 4150.

Scholarships.
Christ Church College, Oxford, physical science studentships (or scholarships); there are to be 31 open junior studentships, besides 21 for Westminster School; of 30 in 1870, 5 were for mathematics and 5 for physical science; few candidates from public schools; senior studentships not awarded for science, 4166–4180, 4217.
Not more studentships at Christ Church than are required for college business, 4187.
Admission of Oxford science students to scholarships, but not to fellowships without taking a pass degree, could not be a permanent system, 4205.
Number of candidates for Christ Church open studentships does not imply need of more professors, 4207.
For Christ Church studentships, anatomy, chemistry, or physics is required, with any special subject, 4214.

Schools.
Alteration in school education essential to increase science candidates at Oxford University, 4175.
For Christ Church College studentships there have been but few candidates from the great public schools, 4175, 4217.
While university fellowships are given for one kind of education, schools will prepare with special reference to it, 4218.

Liddell, Very Rev. H. G.—cont.

Science.
- Examination for studentships at Christ Church College, Oxford, is in anatomy, chemistry, or physics; special subjects may be added, 4214.
- All persons taking degrees of science at Oxford University should show literary culture, 4204.
- Scientific without literary culture would not be a satisfactory education, 4220.
- Literary education at Oxford University is not altogether without science, 4221.
- Pass-men (not honours' men) at Oxford should exhibit both literature and science; pass-men are not obliged to do so now, 4183–4186, 4195.
- Objection to scientific work being added to final classical schools at Oxford University, 4200, 4201, 4222.
- Desirable that persons taking classical honours at Oxford should exhibit knowledge of science; but not to be recommended at present, 4202.
- Where science is severely studied as at Oxford University, doubtful if students would prefer it to classics, 4176.
- Science could be promoted at Oxford University by enlargement of present means; supply is equal to demand now, 4178.
- Dr. Lee's foundation at Christ Church College, Oxford; more than half applied to science; all will be applicable, if required, 4145–4148.
  - See *Christ Church College (Oxford).*

Students.
- Christ Church College, Oxford, students; number at Lee readers' lectures not large; generally are men going out in honours; all attend museum; not many for science studentships; not up to mark; senior students few; mostly reside in college; all employed in college work, 4158–4165, 4170–4182, 4207, 4214.
- Considerable increase of students in museum at Oxford, 4163.
- Students would prefer classics where science is severely studied, 4176.
- Enlargement of present means of Oxford University is sufficient to encourage students, 4178.
- Oxford pass-men; should show literature and science; they have more difficult examination than formerly—more mathematics; necessity of producing exact knowledge is the difficulty with pass-men, 4183–4186, 4194–4196.
- Honours' men at Oxford can pursue their own lines of study after a certain time; they should exhibit literary knowledge, but at any period, 4197–4199.
- Literary culture should be required of all Oxford students, 4200–4204.
- Admission of Oxford science students to scholarships and honours, but not to fellowships without taking a pass degree, could not be a permanent system, 4205.
- With more fellowships at Oxford, there might be more scientific students, 4216, 4217.

Studentships. See *Scholarships.*

Teachers. See *Assistant Professors, &c.*

Westminster School.
- Twenty-one studentships at Christ Church College, Oxford, are set apart for boys from Westminster School, 4170.

SCOTT, The Very Rev. ROBERT, D.D. (Index of his Evidence.)

Accommodation for Science Purposes.
- Museum buildings, &c. at Oxford have been munificently contributed to by colleges, 4859.

Age of Students.
- Older students enter Oxford and Cambridge now from Scotch Universities; Balliol College undergraduates have matriculated at 25 years, 4848.

Apparatus for Science Purposes.
- Teaching apparatus and appliances at Oxford University have been liberally contributed to by the colleges, 4859.

Assistant Professors, Teachers, &c.
- Science teaching in endowed schools may increase the number of Oxford men studying to become teachers, 4878.

Balliol College (Oxford).
- Chemical laboratory at Balliol College formerly; not used now, 4820, 4836.
- Students of Balliol College; good competitors for natural science scholarships; many students become teachers in schools, 4820–4823, 4877.

Scott, Very Rev. R.—*Balliol College (Oxford)*—cont.
- Balliol College fellowships, scholarships, and exhibitions; no fellowships for natural science; scholarships for natural science in alternate years; mathematical scholarship lately instituted; exhibitions, 4820–4826, 4829–4832, 4841–4843.
- Examinations at Balliol College; same examination for scholarships and exhibitions, 4826, 4827, 4841–4843.
- Combination of Balliol and New Colleges for lecture purposes, 4834.

Cambridge University.
- Tendency of Cambridge students to matriculate at a later age, 4848.
- Students having the Cambridge degree are admitted to Oxford University; they may then pursue science alone, 4849–4852.

Chemistry.
- Balliol College, Oxford, founded a chemical laboratory; not used now; students go to University laboratory, 4820, 4836.

Degrees.
- Cambridge degree is accepted for admission of students by Oxford University; they may then pursue science alone, 4849–4852.
- For Oxford pass degrees Greek should be required, except where great attainment in another shape might be procured, 4875, 4876.

Education.
- Teaching of Oxford University is in the direction of classics rather than of science, 4844, 4845.
- Preciousness of the study of language as an element of training, 4846.

Examinations.
- Examinations for Balliol College exhibitions comprise classical, mathematical, historical, and scientific subjects, 4826, 4827.
- Balliol College scholarships and exhibitions are filled up from same examination, 4841–4843.
- In an initiatory examination at Oxford of students entering from endowed schools, literature might be lessened, 4846–4848.

Exhibitions. See *Scholarships and Exhibitions.*

Fellowships.
- No fellowship for natural science has been given by Balliol College; college might do so, but the few fellowships and difficulty of securing tutorial staff are drawbacks, 4829.
- Greater part of Balliol College fellows are employed in college work, 4830–4832.
- Many fellowships in different colleges at Oxford have been annexed to professorships, 4837.
- Objection to diminishing number of fellowships; restriction of tenure, in case of non-residents, preferable, 4838–4840, 4860, 4861.

Glasgow University.
- Undergraduates from Glasgow University have matriculated at Balliol College, Oxford, as late as 25 years, 4848.

Greek.
- Importance of requiring Greek at Oxford University, except where great attainment in another direction might be gained, 4855, 4856, 4875.
- Intrinsic value of Greek far above that of Latin, 4864–4868.

Income and Expenditure.
- Oxford University has devoted all its savings for the last 10 years to the prosecution of science, 4837.
- Colleges at Oxford have contributed munificently to promote science in the University; out of their surplus funds colleges might form science endowments for themselves; unwillingness of some colleges to appropriate their funds to University, 4859–4863.

Laboratories.
- Chemical laboratory formerly at Balliol College, Oxford; students work in University laboratory now, 4820, 4836.

Languages.
- Value of the study of languages as an element of training, 4846, 4864–4876.
- Importance of Greek; its superiority to Latin, 4855, 4856, 4864–4868, 4875.
- Study of a dead language more scientific than study of a living one, 4869–4874.

Latin.
- Latin is of more use in common life, but Greek is infinitely above it in intrinsic value, 4864–4868.

Scott, Very Rev. R.—cont.

Lectures.
- Combination of Balliol College and New College, Oxford, for lecture purposes, 4834.

Literature.
- Case of a successful competitor for a Balliol College natural science scholarship being found wanting in classics, 4822, 4823.
- Balliol College scholarships generally are distinctively classical, 4825.
- The character of Oxford University is literary, 4844, 4845.
- At Oxford, literature might be lessened (not given up) in the case of pupils entering from endowed schools, 4846–4848, 4852.
  - See *Languages.*

Mathematics.
- Mathematical scholarship lately instituted at Balliol College, Oxford, 4824.

New College (Oxford).
- Combination of New College and Balliol College for lecture purposes, 4833.

Oxford University.
- Colleges at Oxford; their combination may promote science; their munificent contributions to museums, &c.; might form collegiate endowments for science; indisposition of some to appropriate their endowments to University, 4833–4837, 4859–4863.
- Oxford fellowships and scholarships; many fellowships annexed to professorships; objection to diminishing number of fellowships; more scholarships wanted for science, 4837–4840, 4857, 4858, 4860, 4861.
- Character of Oxford University is distinctly literary, 4844, 4845.
- Oxford students; matriculate later; attracted by science, but not greatly; more science scholarships should be offered them, 4846–4848, 4852–4854, 4857, 4858, 4864–4878.
- Oxford examinations; initiatory examination of pupils from endowed schools undesirable, 4846–4848.
- Cambridge degree accepted by Oxford University for admission of students who desire to pursue science alone, 4849–4852.
- Importance of retaining Greek at Oxford University, 4855, 4856, 4875.
- Oxford professorships; University has dealt liberally with those for science, 4857, 4859.
- Oxford degrees; Greek should be required for pass degrees, except where special attainment is shown, 4875, 4876.
  - See *Balliol College (Oxford).*

Professorships.
- Many fellowships in different colleges at Oxford have been annexed to professorships, 4837.
- Oxford University has dealt liberally with scientific professorships, 4857, 4859.

Scholarships and Exhibitions.
- Natural science scholarships at Balliol College, Oxford, given in alternate years; tenable for three years; candidates fairly good, 4820–4822.
- Mathematical scholarship lately instituted at Balliol College, 4824.
- Balliol College scholarships generally are distinctively classical; difficult to alter them, 4825.
- Minor exhibitions lately created at Balliol College; natural science included with other subjects, 4826.
- Scholarships given by some colleges at Oxford; might be more extended to science students, 4837, 4857–4859.
- Balliol College exhibitions are filled up from same examination as scholarships; by resolution of college, they might be given for science, 4841–4843.

Schools.
- Literature might be lessened (not given up) for pupils from endowed schools entering Oxford to study science, 4846–4848, 4852.
- More students at Oxford would be attracted to science if preparation in public schools were better, 4853, 4854.
- Many Balliol College students have become teachers in schools, 4877.
- Teaching of science in endowed schools may increase number of Oxford men studying for teachers, 4878.

Science.
- Promotion of science at Balliol College, Oxford, 4819–4879.
- Science promoted at Oxford by combination of colleges; the University has devoted all its savings for the last 10 years to science, 4833–4837.

Scott, Very Rev. R.—cont.

Scotland.
- Students from Scotch Universities enter Oxford and Cambridge later than formerly, 4848.

Students.
- Balliol College chemistry students work in University laboratory, instead of in their own, 4820.
- Good candidates have competed for Balliol College natural science scholarships; case of successful candidate being found wanting in classics, 4822, 4823.
- Literary requirement might be lessened (not given up) for Oxford students entering from endowed schools, 4846–4848, 4852.
- Tendency of students to matriculate later at Oxford and Cambridge; undergraduates from Glasgow have matriculated at Balliol College as late as 25 years, 4848.
- Oxford students are attracted by the science course, but less than could be wished, 4853, 4854.
- Scholarships at Oxford should be more extended to science students, 4857, 4858.
- Oxford pass-men should exhibit Greek, except where great attainment of another kind might be shown, 4875, 4876.
- Value to students of training by language, 4846, 4864–4876.
- Many Balliol College students become teachers in schools, 4877.
- Science teaching in endowed schools may increase number of Oxford men studying for teachers, 4878.

Teachers. See under *Assistant Professors, &c.*

FOWLER, The Rev. THOMAS, M.A. (Index of his Evidence.)

Appointments.
- Oxford University professors should take part in appointment of assistant professors; variety in mode of appointment of professors desirable, 13,721–13,726.

Assistant Professors.
- Importance of instituting a new class of assistant professors at Oxford University, 13,668–13,752.
- At Oxford University, the terms "professors" and "professors-in-chief" would be preferable to "assistant professors" and "professors," 13,718.

Colleges.
- Smallness and isolation of colleges are obstacles to collegiate teaching at Oxford; some colleges should be grouped, 13,676–13,699, 13,730–13,748.

Education.
- Education at Oxford University; professorial, tutorial, and private teaching; latter decreasing, 13,659–13,752.

Examinations.
- Establishment of new schools of examination at Oxford University has extended the curriculum, 13,700.

Fellowships.
- Fellowships at Oxford; terminable fellowships suggested; opinion favourable to converting many fellowships into professorships, 13,737, 13,745.

Income and Expenditure.
- Revenues of Oxford University, even after re-distribution, will not allow large stipends, 13,669.
- Desirability of instituting terminable professorships at Oxford University, with 300*l.* or 400*l.* income, 13,669.
- Economy of funds would result from fusion of colleges at Oxford University, 13,730–13,735.

Lectures
- Advantage of combining lectures at Oxford University; system transitional; scheme could be better carried out by University, 13,661–13,666, 13,678–13,699.
- At Oxford University, professors, assistants, and teachers should meet each term to arrange their lectures, 13,749–13,751.

Original Research.
- Oxford professors should be greatly engaged in the advancement of learning and science, 13,674, 13,675.

Oxford University.
- Oxford University; a hierarchy of offices essential; organization of University and its colleges desirable; obstacles to fusion of corporations, 13,658–13,752.
- Governing bodies of colleges at Oxford should be reorganized, 13,737–13,739.
- Proposals for improvement of Oxford University, 13,752.
  - See *Professorships, &c.*

Fowler, Rev. T.—cont.

Professors.

Oxford University professors; increased number desirable; they should have assistants, and time for research, 13,658–13,752.

Professorships.

At Oxford University, there should be new professorships for subjects unrepresented; assistant professorships for subjects widely studied; and non-resident terminable professorships for lecture purposes, 13,658–13,752.

Oxford University desirous of converting many fellowships into professorships, 13,745.

Desirability of founding professorships, &c. within the colleges at Oxford University, 13,737.

Science.

Increase of professoriate at Oxford University desirable, chiefly for natural science, 13,668–13,752.

Students.

Students of Oxford University would greatly benefit by extension of professoriate and grouping of colleges, 13,667, 13,689, 13,690.

LAWSON, Professor MARMADUKE, M.A. (Index of his Evidence.)

Accommodation for Science Purposes.

Accommodation at Oxford Botanic Garden; houses, cabinets, &c. required; library should adjoin herbarium and museum, 13,754–13,810.

Botany.

Botanic Garden of Oxford; founded for scientific instruction and research; it wants funds, additional houses, &c., 13,754 13,810.

Valuable herbarium at Oxford Botanic Garden, 13,759, 13,760, 13,795–13,797, 13,806–13,809.

Lawson, Professor—*Botany*—cont.

Botany almost ignored at Oxford University; it should be promoted by a scholarship, &c., 13,761–13,780, 13,811, 13,812.

Degrees.

Botany should be required for a degree in the biological school at Oxford University, 13,761–13,780.

Examinations.

In biological examinations at Oxford University botany has no place, 13,779, 13,780, 13,814.

Income and Expenditure.

Funds wanted for Oxford Botanic Garden; income 530*l.* and 100*l.* for repairs, 13,755, 13,770, 13,781–13,783.

Libraries.

Library at Oxford Botanic Garden should adjoin herbarium and museum, 13,759, 13,760, 13,798.

Museums.

Museum at Oxford Botanic Garden ought to be remodelled, 13,759, 13,760, 13,798, 13,804.

Original Research.

Botanic Garden of Oxford was founded for scientific research, 13,754.

Oxford University.

Botanical science at Oxford University; almost ignored; it should be essential for degree, &c., 13,753–13,815.

Scholarships.

No scholarships at Oxford University for botany; even a small one would be valuable, 13,775, 13,811–13,814.

Students.

Few students of botany at Oxford University; a scholarship would attract them, 13,772, 13,799–13,803, 13,811, 13,812.

University of Cambridge.

CHALLIS, Rev. JAMES, M.A. (Index of his Evidence.)

Accommodation for Science Purposes.

Want of accommodation for experiments in physics at Cambridge University; remedy in progress, 4234, 4235, 4239.

Laboratories for physical teaching provided by some colleges at Cambridge University, 4240.

Airy, Professor.

Professor Airy's lectures at Cambridge University in 1826 gave a great impulse to study of physics, 4232, 4284.

Apparatus for Science Purposes.

Want of physical apparatus at Cambridge University; remedy in progress, 4234, 4235, 4243.

Assistant Professors, Demonstrators, and Teachers.

Demonstrator and assistant for experimental physics to be appointed in Cambridge University, 4235, 4291.

Tutorial teaching is adapted to general students; professorial teaching to the higher class, 4242.

Astronomy.

Astronomical physics is the special department of the Cambridge Lowndean professor, 4236.

Botany.

Cambridge candidates for an ordinary degree might attend lectures on botany, 4265, 4267.

Botany is an educational study, but in a different sense from the study of physics associated with mathematics, 4267.

Cambridge Observatory.

Plumian professor of astronomy is chiefly confined to direction of Cambridge Observatory, 4228.

Cambridge University.

Professors at Cambridge; Lucasian, Plumian, and Lowndean; book of Plumian professor, written to promote physical science; new professor of experimental physics; one probably not sufficient; 30 students sufficient for one professor, 4231, 4232, 4249, 4291–4294.

Mathematical lectures at Cambridge have been directed to instruction of honours' candidates, 4231.

Honours' course at Cambridge; heat, electricity, and magnetism introduced; applied mathematics an essential, 4231–4238, 4249–4254.

Physical science at Cambridge; appliances for experiments wanting; experimental physics' instruction supplied by mathematical professors; laboratories provided by some colleges; endowment of new professorship; former and present state of physical science, 4232–4247, 4250–4257, 4280, 4284, 4285.

Challis, Rev. J.—*Cambridge University*—cont.

Students at Cambridge; honours' candidates in mathematical departments; candidates for degrees must attend certain lectures and obtain certificates; physical science students should attend lectures of two professors, one being for experimental physics, 4231, 4240–4248, 4258–4265, 4274–4280, 4288–4290, 4295, 4300–4302.

Cambridge fellowships; one for physics awarded by Trinity College, 4255–4257.

Degrees at Cambridge; candidates must have attended certain lectures, and must pass two examinations; more physical science should be required, 4258–4265, 4271–4281.

Cambridge fellowships; desirable to award them for physics; suitable candidates would be found, 4297–4301.

Chemistry.

Chemistry regarded as an application of the higher physics, 4267–4270.

Children.

School-boys should be instructed in classics and mathematics; those who stay long, in physics, 4303.

Cost, Expenditure, &c.

Each member of Cambridge University is to pay 17*s.* a year for endowment of professorship of experimental physics, 4243, 4282.

Degrees.

The experimental physics' teaching at Cambridge University will be appropriate to candidates for ordinary degrees, 4235.

At Cambridge University each candidate for ordinary degrees must have attended the lectures of some professor, the four mathematical professors being excepted, 4246, 4258, 4264.

Two examinations must be passed by Cambridge candidates for ordinary degrees; they may then devote themselves to any particular study, 4259–4262.

Few candidates for ordinary degrees at Cambridge attend lectures of Plumian professor, 4263.

Certificates of attendance on lectures for Cambridge B.A. degree are given by professors of chemistry, botany, geology, anatomy, and zoology, 4264.

Candidates for ordinary degrees at Cambridge (previously instructed in mathematics and classics) might attend lectures on botany, geology, or zoology, 4265.

More physical science should be required before taking a degree at Cambridge University, 4271–4280.

For Cambridge B.A. degree, physical science need not be taken; if taken, a certificate of attendance on some

Challis, Rev. J.—*Degrees*—cont.
professor's lectures must be produced, 4274–4279, 4288–4290.
Professor of modern history at Cambridge can give certificate for degree of B.A., 4280, 4281.
At Cambridge University the fellowship is mostly determined by result of degree examination, 4297.
See *Honours.*

Downing College (Cambridge).
Fellowship for physics awarded by Downing College, 4300.

Education.
Classics and mathematics prepare for receiving benefit from other kinds of lectures, 4265.
For an ordinary physical education, Euclid and the elements of mathematics are alone essential, 4267.
School-boys' instruction should be devoted to classics and mathematics; with physics, for those who stay long, 4303.

Electricity. See *Physics*

Endowment.
Endowment of professors and assistants for experimental physics at Cambridge University, 4243.

Euclid.
Euclid, and the elements of mathematics, are all that is essential to an ordinary physical education, 4267.

Examinations.
Heat, electricity, and magnetism recently introduced in examinations for honours at Cambridge University, 4235, 4238.
Examinations for Dr. Smith's prizes at Cambridge; high mathematical qualifications of candidates, 4247, 4250.
Candidates for ordinary degrees at Cambridge University must pass two examinations, 4262.
Examination questions for mathematical honours at Cambridge are too abstract, 4286, 4287.
Professors' lectures to be attended, and certificates obtained, after examination, by all candidates for degrees at Cambridge University; public examinations for certificates are held now by examiners appointed by University, 4271–4281, 4288–4290.

Fellowships and Scholarships.
Cambridge fellowships an inducement to students to study physics, 4245–4247.
Fellowships for physics given by Trinity and Downing Colleges, Cambridge, 4255, 4300.
Fellowships for physics (united with mathematics) should be increased, 4256, 4257, 4298, 4299.
In most colleges at Cambridge the fellowship is determined by result of degree examination, 4297.
If more physical science fellowships were awarded at Cambridge University, suitable candidates would be found, 4301.
Advantage of awarding scholarships for physics at Cambridge University, 4302.

Geology.
Candidates for ordinary degrees at Cambridge University might attend lectures on geology, 4265, 4267.
Geology is an educational study, but educational in a different sense from physics associated with mathematics, 4267.

Heat. See *Physics.*

Honours.
Cambridge University mathematical lectures have been directed to instruction of honours' candidates, 4231.
Heat, electricity, and magnetism recently introduced into curriculum for honours at Cambridge University; optional subjects, 4235, 4249, 4251–4254.
The wants of Cambridge honours' candidates, in regard to experimental physics, have been met by the mathematical professors, 4240.
Honours' course at Cambridge University has gone too much into abstractions; it should be directed into applied mathematics, 4249, 4286, 4287.

Laboratories.
Some colleges at Cambridge have begun physical teaching, and have laboratories, 4240.

Lectures.
The mathematical lectures at Cambridge University have been directed to instruction of honours' candidates, 4231.
The lectures to be given at Cambridge University on experimental physics will be appropriate to candidates for ordinary degree, 4235.
The lectures of some professors (excepting mathematical professors) must have been attended by candidates for degrees at Cambridge University, 4246, 4258, 4261, 4274–4281.
Plumian professor's lectures at Cambridge attended by few candidates for ordinary degrees, 4263

Challis, Rev. J.—*Lectures*—cont.
Certificates of attendance on lectures for Cambridge B.A. degree are given by professors of chemistry, botany, geology, anatomy, and zoology, 4264.
Lectures on botany, geology, or zoology might be attended by candidates for ordinary degrees at Cambridge University, 4265.
Specific education in classics and mathematics prepares for other kinds of lectures, 4265.
Attendance of students at lectures; large number attending Scotch professors; 30 the maximum for one professor, 4291–4294.
Scotch professors' lectures are simply prælections, 4294.
Professors' lectures at Cambridge are not likely to be lowered on account of attendance of pass-men, 4295.

Literature.
Specific education in classics and mathematics prepares for other kinds of lectures, 4265.
Classics and mathematics should form the instruction of school-boys, 4303.

Lowndean Professor. See *Cambridge University.*

Lucasian Professor. See *Cambridge University.*

Magnetism. See *Physics.*

Mathematics.
Cambridge University mathematical professors; their instruction is directed to honours' candidates, 4231, 4240.
Application of mathematics an essential in duties of professor of astronomy and experimental philosophy, 4232.
Few scientific students at Cambridge University in departments connected with mathematics, 4248.
Honours' course at Cambridge requires to be directed to applied more than to pure mathematics, 4249, 4286, 4287.
For mathematical honours' candidates at Cambridge, physics' subjects will be optional, 4251.
Cambridge fellowships should not be given for physics, without mathematics, 4256, 4257.
Specific education in classics, and mathematics, prepares for other kinds of lectures, 4265.
Physics should always be studied in connexion with mathematics, 4266, 4296.
Euclid, and the elements of mathematics, are all that is essential to an ordinary physical education, 4267.
Mathematics, and classics, should form the instruction of school-boys, 4303.

Natural Philosophy. See *Physics.*

Physics.
Theoretical physics is in arrear of experimental; Cambridge University professors should cultivate the former, if the latter be taken care of, 4232–4234.
Want of buildings, &c., at Cambridge, for experiments in physics; remedy in progress, 4234, 4235.
Professor, demonstrator, &c., for experimental physics, proposed for Cambridge University; doubtful if one professor will be sufficient, 4235, 4243, 4244, 4291.
Heat, electricity, and magnetism recently introduced into honours' curriculum at Cambridge University; optional subjects, 4235, 4249, 4251–4253.
Astronomical physics is the department of the Lowndean professor at Cambridge, 4236.
Physics not sufficiently attended to at Cambridge University; mathematical studies resting with private tutors, 4237.
The museums' building at Cambridge is inadequate for teaching physics; new building wanted, 4239.
No professor of experimental physics at Cambridge University hitherto, but mathematical professors have met wants of honours' candidates, 4240.
At Cambridge, the teaching of physics in colleges has been unconnected with the professors, 4241.
At Cambridge University, physics is studied as a matter of taste, or in view of fellowships or professorships in educational institutions, 4245–4247.
Physical subjects, when introduced at Cambridge University, will probably be attended to; they will be optional for mathematical honours' candidates, 4250–4254.
Trinity College, Cambridge, has awarded a fellowship for physics; increase of such fellowships desirable, 4255–4257.
Physics should not be studied apart from mathematics, 4266, 4296.
Euclid, and the elements of mathematics, are all that is essential to an ordinary physical education, 4267.
Chemistry regarded as an application of the higher physics, 4267–4270.
For degrees at Cambridge University, more physical science should be required, 4271–4280.

Challis, Rev. J.—*Physics*—cont.

Physical science need not be taken for Cambridge B.A. degree; if taken, a satisfactory certificate of attendance on the lectures of some professor in the physical department is essential, 4274–4279, 4288–4290.

Cambridge students should attend lectures of two professors, one being professor of experimental physics, 4280.

State of physical science at Cambridge University; Professor Airy's lectures in 1826, continued by Plumian professor, and by Professor Stokes; the study has not fallen off, 4284, 4285.

Desirability of awarding more fellowships and scholarships in physics at Cambridge University; candidates will be found, 4297–4302.

Boys who stay long at school might receive instruction in physics, 4303.

Plumian Professor. See *Cambridge University.*

Professors.

Cambridge University professors should cultivate theoretical, rather than experimental physics, if latter be taken care of, 4227–4234.

Professor of experimental physics to be appointed at Cambridge University; his teaching will be appropriate to candidates for an ordinary degree; doubtful if one professor will be sufficient, 4235, 4291.

The Lowndean professor at Cambridge University teaches astronomical physics, 4236.

The Cambridge mathematical professors have hitherto met the wants of honours' candidates in respect to experimental physics, 4240.

Teaching of physics in colleges at Cambridge is unconnected with professors, 4241.

Professorial teaching is adapted to higher students; tutorial teaching to the generality, 4242.

Candidates for ordinary degrees at Cambridge must have attended certain lectures of some professor; mathematical professors excepted, 4258, 4264.

Few candidates for ordinary degrees at Cambridge have attended lectures of Plumian professor, 4263.

Professors of chemistry, botany, geology, anatomy, and zoology at Cambridge give certificates of attendance on lectures for B.A. degree, 4264.

Candidates for Cambridge B.A. degree, taking up physical science, must produce certificate of attendance on some professor in the physical department, 4274–4279, 4288–4290.

Attendance upon lectures of two professors, one being professor of experimental physics, should be required of students at Cambridge, 4280.

Professor of modern history at Cambridge University can give certificate for B.A. degree, 4280, 4281.

Two professors of one subject might divide the labour; responsibility should not be borne by one only, 4292.

Large numbers of students attending Scotch professors; 30 students the maximum one professor can well attend to, 4293, 4294.

Professorships.

Endowment of professorship of experimental physics at Cambridge University; 17*s.* a year to be paid by each member, 4243, 4291.

School.

Boys at school should be educated in classics and mathematics; those who stay long, in physics, 4303.

Scholarships. See *Fellowships and Scholarships.*

Science.

The foundation of science must be laid in experiment, 4233.

Union should be kept up between mathematics and physics, 4256, 4266–4270.

Botany, geology, or zoology might be studied by candidates for ordinary degrees at Cambridge University, 4265.

Chemistry regarded as an application of the higher physics, 4267–4270.

See *Cambridge University.*

Scotland.

Large number of students attending professors' lectures in Scotland, 4293, 4294.

Smith, Dr.

Candidates for Dr. Smith's prizes at Cambridge University are mathematicians of the highest order; they obtain positions in educational institutions, 4247, 4250.

Stokes, Professor.

Continuation, by Professor Stokes, of Professor Airy's lectures on physical optics at Cambridge University, 4284.

Challis, Rev. J.—cont.

Students.

Cambridge University students attending mathematical professor's lectures are honours' candidates, 4231.

Wants of Cambridge honours' candidates, regarding experimental physics, have been met by mathematical professors, 4240.

Professorial teaching is adapted to the higher class of students; tutorial to the generality, 4242.

Cambridge students of physics study from taste, or for fellowships or professorships in educational institutions, 4245–4247.

Cambridge candidates for degrees must attend certain lectures of some professor, and pass two examinations; few attend Plumian professor's course; they might attend courses in botany, geology, or zoology, 4246, 4258–4265, 4274–4280, 4288–4290.

Few Cambridge students of science connected with mathematical departments; their preference for pure mathematics, 4248, 4249.

Candidates for degrees at Cambridge attend lectures of certain professor chiefly with the view of obtaining certificate for degree examination, 4288–4290.

Lectures of Scotch professors are attended by a large number of students; 30 students are sufficient for one lecturer, 4292, 4293.

Attendance of pass-men on professors' courses at Cambridge not likely to lower character of lectures, 4295.

Suitable candidates will not be wanting for Cambridge fellowships and scholarships in physics, 4300–4302.

Teachers. See *Assistant Professors, &c.*

Trinity College (Cambridge).

Trinity College has awarded a fellowship for mathematics; candidates have acquitted themselves well, 4255–4257, 4300.

Zoology.

Candidates for ordinary degree at Cambridge University might attend lectures on zoology, 4265.

ADAMS, **Professor** J. C., M.A. (Index of his Evidence.)

Airy, Professor.

Light was thoroughly studied at Cambridge University, under Professor Airy, 4324.

Astronomy.

Yearly lectures on physical astronomy at Cambridge University; six or seven of the higher men attend, 4306, 4307.

Cambridge Observatory.

Observatory at Cambridge is at present in charge of Lowndean professor of astronomy, 4305.

Cambridge University.

Cambridge professors; Lowndean professor of astronomy; collegiate instruction should be independent of professors; the professors have leisure for research; their election to fellowships, 4304–4307, 4327–4334.

Lectures at Cambridge; one course yearly on physical astronomy; most lectures accompanied by examination; attendance on physical science lectures should be optional, 4306, 4307, 4318–4320, 4329, 4330, 4334.

Cambridge students; six or seven attend Lowndean professor; students from all colleges admitted to laboratories; few students qualified for natural science scholarships, 4307, 4318, 4325, 4326, 4334, 4337.

Physical science at Cambridge; should be carried on with mathematics and literature; not to be indispensable for degree; laboratories; physics should be voluntarily studied, 4308–4317, 4323–4326, 4334, 4339, 4346, 4354.

Approval of Cambridge system, which requires a foundation in classics and mathematics, 4311.

Science has not been properly recognised at Cambridge University; but some branches, as light, have been thoroughly studied, 4323, 4324.

Cambridge professorships; expected advantage from new professorship of experimental science; supplementing endowment of professorship by fellowship desirable, 4323–4326, 4332, 4354.

Colleges at Cambridge; their encouragement of physical science; college funds; difficulties respecting taxation, 4323–4327, 4340, 4341, 4349–4355.

Fellowships at Cambridge; mostly awarded after examination; should be given also for eminence in special study; statutes might require modification to effect this, 4331–4333, 4340, 4341, 4344, 4345.

Cambridge scholarships; objection to young men in their first year holding scholarships; few science scholarships, and few qualified candidates, 4335–4337.

ADAMS, Professor—*Cambridge University*—cont.
- Funds at Cambridge; University chest low; jealousy of colleges at University interference with their funds, 4349–4355.

Challis, Professor.
- Light thoroughly studied at Cambridge University under Professor Challis, 4324.
- Professor Challis lately re-elected to a fellowship at Trinity College, 4333.

Children.
- Schoolboys should have any decided taste developed; classics and mathematics should be required from all, but not science, 4338, 4339.

Cost, Income, and Expenditure.
- Cambridge University chest is extremely low; the demand being equal to its capacity, 4347, 4348.
- Jealousy of colleges at Cambridge as to University interference with their funds; 12,000*l.* a year lately placed at disposal of University; not capable of extension, 4349–4355.

Cramming.
- Devotion to one subject an antidote to cramming, 4321.

Degrees.
- Objection to physical science being made indispensable for Cambridge University degree, 4314.

Downing College (Cambridge).
- Laboratory established at Downing College; students of other colleges admitted, 4326.

Education.
- Scientific study should not be carried on without literature and mathematics, 4308–4312, 4339, 4342.
- Modified system of education might be desirable for professional students, 4342, 4343.

Endowments.
- Election of Cambridge professors to fellowships, where endowment is inadequate, desirable, 4332, 4333.

Examinations.
- Approval of Cambridge University "previous examination," 4311.
- Lectures at Cambridge are mostly accompanied by examinations, 4319, 4320.
- Cambridge fellowships mostly awarded after examination, 4331.

Fellowships.
- Some Cambridge University fellowships should be given for eminence in special studies, to promote original research, 4331, 4344, 4345.
- Fellowships at Cambridge awarded to inadequately endowed professors; Crown assistance necessary to facilitate this, 4332, 4333, 4340, 4341.
- Holders of Cambridge fellowships need not be employed in University work more than at present, 4344.

Laboratories.
- Laboratories at St. John's, Sidney, and Downing Colleges, at Cambridge; others will probably be formed, 4325, 4326.

Lectures.
- Lectures of Lowndean professor at Cambridge University; one course yearly; six or seven of the higher students attend; problems worked and examinations held, 4306, 4307, 4318–4320.
- Most lectures at Cambridge are accompanied by examination, 4319, 4320.
- Professors should lecture, but advance of science should be their main object, 4328.
- Lecture requirements at Cambridge leave time for original research, 4329, 4330.
- Physical science lectures at Cambridge should be attended voluntarily, 4331.

Light.
- Light has been thoroughly studied at Cambridge University, under Professors Challis, Airy, and Stokes, 4324.
  - See *Physics.*

Literature.
- Physics should be studied with literature, not as a substitute for it, 4308.
- Without literature, the mind devoted to material objects becomes narrowed, 4310.
- Objection to schools which would exclude literature, 4310, 4342.
- Approval of Cambridge University system, which requires a foundation both in classics and mathematics, 4311.
- After a certain amount of culture, classics might be laid aside, 4312.
- Classics, with mathematics, a groundwork for all other study, 4339.

ADAMS, Professor—cont.

Lowndean Professor. See *Cambridge University.*

Mathematics.
- Mathematics indispensable to study of physics, 4308–4310.
- Objection to schools where scientific takes the place of mathematical studies, 4310.
- Approval of Cambridge University system, which requires a foundation in classics and mathematics, 4311, 4339.
- After proper culture, mathematics and science might be studied solely, 4312.

Original Research.
- Advancement of science by research, &c., should be the main duty of a professor, 4328.
- Cambridge University lecture requirements leave professors time for original research, 4329, 4330.
- Cambridge fellowships might be utilized for purposes of original research; this is done to some extent, 4331–4333, 4344, 4345.

Parliament.
- Legislative aid essential to facilitate election of eminent men (not students of the University) to Cambridge fellowships, 4340, 4341.

Physics.
- Study of physical science should be encouraged, but should be carried on with mathematics and literature, 4308, 4310.
- Thorough knowledge of mathematics essential to establishment of physical theories, 4308, 4309.
- Physical studies would not occupy majority of students with advantage; opportunity should be afforded to those who desire such study, 4313, 4346.
- Objection to physical science being made indispensable for university degree, 4314.
- Physical science professor at Cambridge University; will attract students; their attendance should be voluntary, 4323–4325, 4331, 4354.
- Some branches of physics, as light, have been thoroughly studied at Cambridge, 4324.
- Physical laboratories at St. John's, Sidney, and Downing Colleges; others will probably be formed, 4325, 4326.

Professors.
- Lowndean professor of astronomy at Cambridge University gives one course annually; knows capacity of his students, 4306, 4307, 4318, 4319.
- Where a student devotes himself to a particular subject, the guidance of a good professor is essential, 4317.
- Instruction in colleges at Cambridge should not be under guidance of professors, 4327.
- Professors should lecture, but their main object should be to advance science, 4328.
- Students work when led by professors of original power, 4328, 4334.
- Cambridge professors have leisure for original research, 4329, 4330.
- Professors elected to Cambridge fellowships where endowment is inadequate; approval of this, as promoting original research, 4332, 4344, 4345.

Professorships.
- New professorship of experimental science at Cambridge University will give impetus to scientific study; disposition of colleges to consent to a tax for this purpose, 4323–4325, 4354.
- Approval of inadequately endowed professorships at Cambridge being supplemented by fellowships, 4332.

Saint John's College (Cambridge).
- Laboratory established at St. John's College; students of other colleges admitted, 4326.

Scholarships.
- Objection to scholarships for young men; if given too early, they defeat their own purpose, 4335, 4336.
- Few science scholarships at Cambridge; number increasing; few qualified candidates, 4337.

Schools.
- Objection to schools in which scientific studies take the place of literary or mathematical, 4310, 4342.
- Schools have not devoted themselves much to physical science, 4338.
- Boys in schools should have any decided taste developed; classics and mathematics (but not science) should be required from all, 4338, 4339.
- A technical school desirable, but not as a substitute for a university, 4313.

Science.
- Study of science should be carried on with literature and mathematics, 4308, 4312.

Adams, Professor—*Science*—cont.

Science not advantageous to those who cannot understand the scientific connexion of the different parts of a subject, 4322.

Pure science would gain little by the offer of immediate pecuniary advantages, 4336.

Sidney College (*Cambridge*).

Laboratory established at Sidney College; students of other colleges admitted, 4326.

Stokes, Professor.

Light thoroughly studied at Cambridge University under Professor Stokes, 4324.

Students.

Cambridge University students; laboratories open to all students; their attendance on physical science lectures should be optional; but few qualified for natural science scholarships, 4307, 4318, 4325, 4326, 4334, 4337.

Students of science cannot dispense with the mental training supplied by mathematics and literature, 4308.

After proper culture, students might devote themselves solely to mathematics and physical science, 4312.

Majority of students would not work advantageously at physical studies; those who desire it should have opportunity of study afforded them, 4313, 4346.

Students should be encouraged to prosecute special studies; they should have the guidance of a professor, 4315–4317.

Science, unless studied systematically, would be of little advantage to students, 4322.

Students work when led by professors of original power, 4328.

Objection to first-year students receiving scholarships, 4335, 4336.

Professional students might have a modified system of instruction, 4342.

Technical Instruction.

A technical school desirable, but not as a substitute for a university, 4343.

HUMPHRY, Professor GEORGE MURRAY, F.R.S.

(Index of his Evidence.)

Accommodation for Science Purposes.

Two buildings at Cambridge University for study of anatomy; capable of addition; more rooms needed for dissections; library in connexion wanted; museums should be under government of University, 4361, 4365, 4394, 4395, 4399, 4410–4422, 4436, 4478–4482.

See *Laboratories.*

Anatomy.

Anatomy is one special subject of examination for natural science degrees at Cambridge, 4386.

Students mostly attend the anatomy lectures at Cambridge with a view to degrees, 4408, 4409.

More dissecting rooms and a library wanted for anatomical teaching at Cambridge, 4410–4422.

Professor of anatomy at Cambridge should have a position in science part of building, 4418.

Professorship of anatomy and physiology at Cambridge University; income about 400*l.* a year; demonstrator attached; a link between university science and practical medicine, 4403–4423.

Examination in anatomy at Cambridge is in part practical, 4453.

Apparatus for Science Purposes.

Models of engines, ships, &c., wanted at Cambridge University for teaching applications of mathematics; large outlay requisite; the gift of the Chancellor will go to remedy the want, 4360, 4361, 4395, 4399, 4400.

Scarcely any philosophical apparatus at Cambridge, except at the Observatory; students have had to go to Paris, &c., for it, 4361.

Architecture.

Architectural models wanted at Cambridge University, 4395.

Assistant Professors, Demonstrators, and Teachers.

College lecturers at Cambridge University fail to interest students; private tutors (teaching being their avocation) do the real work, 4365.

Want of demonstrators at Cambridge to connect teaching with practical laboratory work, 4365, 4395.

Importance of demonstrators as a means of training for higher posts in Cambridge University and elsewhere, 4365.

Humphry, Professor—*Assistant Professors, &c.*—cont.

Demonstrator provided by Cambridge University to assist professor of anatomy, 4405, 4406.

Teacher or demonstrator of practical comparative anatomy wanted at Cambridge, 4417, 4418.

A graduated professoriate of assistant professors, demonstrators, &c., desirable at Cambridge, 4457–4459.

Professors' demonstrators at Cambridge should not be also tutors in colleges, 4465.

Athletics.

Approval of athletics at Cambridge University, 4382, 4383.

Botany.

Examination in botany at Cambridge University is in part practical, 4453.

Caius College (*Cambridge*).

Two fellowships for physicians lately given for classics and mathematics by Caius College, 4371.

Cambridge Observatory.

Scarcely any philosophical apparatus at Cambridge, except at the Observatory, 4361.

Cambridge University.

Mathematical teaching at Cambridge; not sufficiently practical; mathematics should not be a *sine quâ non* for fellowships, 4358–4361, 4363, 4370–4373, 4430, 4442, 4443, 4486–4502.

Professors at Cambridge; want assistants; graduated professoriate desirable, 4358–4361, 4365, 4371, 4372, 4457–4459.

Cambridge students; highly qualified competitors for open science scholarships; advantage socially of students' college life; students of medicine should also attend hospitals; freedom in their studies desirable, 4358–4361, 4365–4369, 4372, 4380–4384, 4389–4393, 4408, 4409, 4423–4430, 4440–4445, 4451, 4452, 4465–4478, 4483–4509.

Apparatus for teaching at Cambridge; very inefficient; models of engines, ships, &c., wanted, 4360, 4361.

Lectures at Cambridge; means of illustration wanted; combination of colleges for lectures might have been wider, 4360, 4361, 4380, 4408, 4409, 4423, 4435–4437.

Accommodation for science purposes at Cambridge; library and more dissection rooms wanted for anatomy; laboratories for physics, &c.; museums should be under government of University, 4361, 4365, 4394, 4395, 4399, 4410–4422, 4436, 4478–4482.

Education at Cambridge; too isolated; should not be separated from religion; rewards should be free from denominationalism, 4362, 4372, 4474, 4475.

Colleges at Cambridge; college lecturers fail to interest students; private tutors do the real work; heads of colleges elected on a bad system; more scientific rewards desirable; approval of combination; college funds should be made contibutory to University instruction; entrance examinations are not universal, 4365, 4377–4379, 4396–4398, 4400–4402, 4435–4437, 4446–4448, 4458–4467, 4479–4485.

Assistant professors and teachers at Cambridge; private tutors do the real work; want of demonstrators, who should not be also college tutors, 4365, 4395, 4405, 4406, 4417, 4418, 4457–4459, 4465.

Examinations at Cambridge; restrict teaching of professors; should be conducted by distinguished men; should be alike for honours' and pass-men; practical examinations in natural science; no matriculation examination at University, 4365–4369, 4385–4391, 4427–4430, 4440–4445, 4453–4456, 4468–4473, 4483–4485.

Cambridge degrees; objection to ordinary degrees; natural science now one mode of obtaining degrees; should be unattainable without literature, 4367, 4385–4388, 4408, 4409, 4431, 4432, 4440–4445.

Cambridge fellowships; diversion of some intended for science; one or two for science should be offered annually; should be free from matrimonial or denominational restriction; mathematical knowledge should not be a *sine quâ non*; objection to length of tenure; desirable that some clergymen obtain fellowships through science, 4370–4376, 4391, 4446, 4512–4516.

Vacations at Cambridge; too long at Christmas, &c.; the long vacation advantageous, 4380, 4381.

Approval of athletics at Cambridge, 4382, 4383.

Natural science tripos at Cambridge; has existed 20 years; has not flourished much; may increase; candidates chiefly medical students; rewards uncertain; proficiency in two subjects only preferred, 4388–4393.

HUMPHRY, Professor—cont.

Chancellor of the University of Cambridge.
Prospect of teaching apparatus at Cambridge being furnished through the gift of the Chancellor, 4361, 4401.

Chemistry.
Laboratories, &c. wanted for teaching chemistry at Cambridge University, 4394, 4395, 4399.
Combination of St. John's and Trinity Colleges, Cambridge, for teaching chemistry, 4436.
Chemistry should be taught in public schools, as essential to students coming to Universities, 4451, 4452.
Examination in chemistry at Cambridge is in part practical, 4453.
In teaching chemistry at Cambridge, theoretical and technical instruction are combined, 4497–4499.

Clergymen.
Cambridge men studying for the Church do not read much science, 4477, 4478.
Desirable that clergymen should have obtained natural science fellowships; general knowledge of science important to them, 4513–4516, 4520–4526.

Cost, Income, and Expenditure.
Large outlay requisite for the laboratories and apparatus needed at Cambridge University, 4394, 4395, 4399.
1,000*l.* to 1,200*l.* a year collegiate funds lately placed at disposal of University at Cambridge, 4402.
For a graduated professoriate at Cambridge, the only source of income would be the colleges, 4457–4463, 4517–4519.
See *Endowment*.

Degrees.
Objection to Cambridge University ordinary degrees; all examination papers should contain questions for the highest man, 4367, 4440–4443.
Natural science examination at Cambridge is now one special mode of obtaining a degree, 4385–4388.
Cambridge students of anatomy work with a view to degrees, 4408, 4409.
Science degrees should not be obtainable at Cambridge without literary culture, 4431, 4432.
Cambridge degree in mathematics alone involves too much mathematical knowledge for a pass man, 4442, 4443.
Ordinary degree man at Cambridge gets up ten or a dozen subjects—honours' man only one; advantage of latter course, 4444, 4445.

Downing College (Cambridge).
Science scholarship given occasionally by Downing College, 4372, 4507.
Chemical laboratory at Downing College; should be combined with others, 4436.

Education.
Education at Cambridge University is too isolated; it should not be separated from religion; rewards should be free from denominationalism, 4362, 4373, 4427, 4474, 4475.

Elections.
Mode of election of heads of college at Cambridge is radically bad, 4377–4379.

Endowment.
10*l.* a year paid to Lucacre Professor at Cambridge, endowment worth about 100*l.*, 4371, 4372.
Cambridge University professor of anatomy receives about 400*l.* a year, 4464.

Engineering.
Want of engineering models at Cambridge University, 4395.
Principles of engineering should be taught at Cambridge; technical teaching would be difficult, 4424, 4426, 4486–4502.
Not many Cambridge students go into engineering, 4476.

Examinations.
Cambridge University professors and tutors restricted by necessity of teaching with a view to examinations, 4365.
Examinations are peculiarly regulators of study at Cambridge, 4366–4368.
Cambridge examinations should be conducted by distinguished men from various parts of the country, 4366.
Objections to examinations for ordinary degrees at Cambridge, 4369, 4389, 4390, 4440–4443.
Examination in natural science is now one special mode of obtaining a degree at Cambridge; not much effect produced at present, 4385–4388.

HUMPHRY, Professor—*Examinations*—cont.
Saint John's is the only college at Cambridge where science forms part of regular examination, 4391.
Too much sameness in Cambridge examinations; independent examiners wanted, 4427–4430.
Well-trained pupils from endowed schools might be admitted to literary examination at Cambridge, and proceed at once with science, 4433, 4434, 4468–4473.
Examinations for pass-men and honours' men at Cambridge should be the same; standard being different, 4440–4443.
Cambridge pass-men and honours' men undergo same qualifying examination, 4444, 4445.
Practical knowledge required for Cambridge natural science examinations; should be also required for physical science, 4453–4456.
No matriculation examination at Cambridge University; preliminary examination after two or more terms; a few colleges have matriculation examinations, 4483–4485.

Examiners.
Importance of having distinguished men as examiners at Cambridge University; Dr. Hooker, Professor Flower, &c. lately appointed, 4366, 4430, 4438.

Fellowships.
Of 400 Cambridge fellowships, about 40 are given annually; more than needed for classics and mathematics; some might be given to science, 4370, 4371.
Only one science fellowship has been given at Cambridge; one or two should be offered annually, 4371, 4396–4398, 4447–4450.
Tendency of certain colleges at Cambridge against giving rewards for science, 4371.
Some Cambridge fellowships, originally intended for science, have been diverted, 4371, 4510–4512.
Cambridge fellowships should be free from matrimonial and denominational restriction, 4373.
Mathematical knowledge should not be a *sine quâ non* for Cambridge fellowships, 4373.
Objection to length of tenure of fellowships at Cambridge; terminable fellowships for university rewards, and non-terminable open to the world, desirable, 4373–4376.
Route through natural sciences' tripos at Cambridge an uncertain avenue to a fellowship, 4391.
Three persons elected to Cambridge fellowships partly for eminence in natural science; Trinity fellowship the only one distinctly for natural science, 4446.
Desirable if some clergymen obtained fellowships through proficiency in science, 4513–4516.

Funds. See *Cost, Income, &c.*

Geology.
Examination in geology at Cambridge University is in part practical, 4453.

Gunnery.
Models of gunnery wanted at Cambridge University, 4395.

Heads of Colleges.
Mode of appointment of heads of colleges at Cambridge is radically bad; fellows, who elect, should be unable to appoint from their own body, 4377, 4378.
If distinguished men were appointed heads of colleges at Cambridge, more work would be done, 4379.

Honours.
All degree examinations at Cambridge University should be for honours, 4367.
Cambridge honours' men and pass-men should have same examination; standard being different, 4440–4443.
Advantage of studying one subject instead of many, like Cambridge honours' men, 4444, 4445.
See *Degrees*.

Hooker, Dr.
Dr. Hooker was the first person, not a member of the university, appointed examiner at Cambridge, 4366.

Hospitals.
Cambridge medical students should attend hospitals, 4423.

King's College (London).
King's College has furnished some of the best competitors for the Cambridge open science scholarships, 4509.

Laboratories.
Great addition wanted to Cambridge University laboratories for experimental physics, mechanics, and chemistry; large outlay requisite, 4361, 4394, 4395, 4399.
Want of demonstrators at Cambridge, to connect teaching with laboratory work, 4365.

HUMPHRY, Professor—*Laboratories*—cont.
  Laboratory of prælector of Trinity is in the new museum, 4419.
  Combination of the laboratories at Cambridge desirable, 4436.
  Laboratories at Cambridge should be more university than collegiate, 4478–4482.
Lectures.
  Apparatus for practical illustration of lectures wanted at Cambridge University, 4360, 4361.
  Prejudicial effect of the vacations at Cambridge on the lectures, 4380.
  About 110 lectures on anatomy given at Cambridge, 4408, 4409, 4423.
  Combination of colleges at Cambridge for lecture purposes; might have been wider, and university more considered, 4435–4437.
Lineacre Professor. See *Professors.*
Literature.
  Cambridge University rewards are chiefly for classics and mathematics; some have been diverted from science, 4370–4372, 4510–4512.
  Without literature, science degrees should not be obtainable at Cambridge, 4431, 4432.
  Well-trained pupils from public schools, entering Cambridge, might be admitted to a literary examination, and enter at once on science, 4433, 4434, 4468.
Marriage of Fellows.
  Matrimonial bar to Cambridge fellowships objectionable, 4373.
Mathematics.
  Mathematical teaching at Cambridge University not sufficiently practical; might be improved without making university a technical school; students would be attracted, 4358, 4359, 4363, 4486–4502.
  Models of ships, engines, &c., wanted at Cambridge, to illustrate application of mathematics, 4360, 4361.
  Cambridge scholarships, &c., have been given almost exclusively for classics and mathematics, 4370–4372.
  Science fellowships at Caius College diverted to mathematics and classics, 4371, 4510–4512.
  For Cambridge fellowships and scholarships, mathematics should not be a *sine quâ non,* 4373.
  Examiners who have seen the application of mathematics to science are wanted at Cambridge, 4430.
  Cambridge degree in mathematics alone involves too much mathematical knowledge for pass-men, 4442, 4443.
Matriculation.
  No matriculation examination at Cambridge University; there is at some of the colleges, 4483–4485.
Mechanics.
  Laboratories, &c., wanted for teaching mechanics at Cambridge University, 4394, 4395, 4399.
Medicine.
  Caius College fellowships for physicians lately given for classics and mathematics, 4371, 4512.
  Professorship of anatomy at Cambridge a connecting link between university science and practical medicine, 4407, 4418.
  Medical teaching at Cambridge should be introductory to actual medical practice; students should attend hospitals, 4423.
  Theoretical and technical medical teaching are combined at Cambridge, 4497.
    See *Students.*
Mineralogy.
  Cambridge examination in mineralogy is in part practical, 4453.
Museums. See *Cambridge University.*
Natural Sciences' Tripos. See *Cambridge University.*
Original Research.
  Graduated professoriate desirable at Cambridge, with principal professor prosecuting research, 4457–4459.
Parliament.
  Application of college funds to University instruction at Cambridge would necessitate legislative interference, 4400–4402, 4457–4463, 4517–4519.
Physics.
  Laboratories, &c., for experimental physics, wanted at Cambridge University, 4394, 4395, 4399.
  Combination of Trinity and St. John's Colleges, Cambridge, for teaching physics, 4436.
  Physics should be taught in public schools, as essential to men coming to University, 4451, 4452.
  Examinations in physics at Cambridge should be in part practical, 4454–4456.

HUMPHRY, Professor—cont.
Physiology.
  Physiology is one of the subjects of examination for natural science degree at Cambridge University, 4386.
  Importance of new prælectorship of physiology at Trinity College; University students can attend the lectures, 4403, 4419, 4420.
    See *Anatomy.*
Practical Instruction.
  Mathematical teaching at Cambridge University is not sufficiently practical, 4358–4361.
  Medical teaching at Cambridge should be introductory to medical practice; students should also attend hospitals, 4423.
  Practical knowledge exacted in Cambridge natural science examinations; should be extended to physical science, 4453–4456.
Prælectorships. See *Trinity College* (*Cambridge*).
Professors.
  Professors at Cambridge University should have apparatus to show application of mathematics, &c., 4358–4361.
  Teaching of Cambridge professors is restricted by necessities of examinations, 4365.
  Professors' assistants wanted at Cambridge, 4365, 4465.
  Lineacre Professor of Medicine at St. John's College receives only 10*l.* a year; endowment being about 100*l.*, 4371, 4372, 4512.
  Graduated professoriate desirable at Cambridge, 4457, 4459.
Professorships. See *Anatomy.*
Religion.
  At Cambridge University education should not be separated from religion; rewards should not be denominational, 4373.
  Science more important to clergymen engaged in tuition than theology to scientific men, 4478, 4513–4516, 4520–4526.
Royal School of Mines.
  For Cambridge open science scholarships, the Royal School of Mines has furnished some of the best competitors, 4509.
Saint John's College (*Cambridge*).
  Lineacre Professor of Medicine at St. John's College; receives only 10*l.* a year, 4371, 4372.
  Saint John's the only college at Cambridge where natural science forms part of regular examination, 4391.
  Combination of St. John's and Trinity Colleges for lecture purposes; St. John's teaching chemistry, 4436.
Scholarships.
  Cambridge University scholarships are given almost exclusively for classics and mathematics; hardly any for science, 4372.
  Open scholarships offered by some colleges at Cambridge; these are drawing good men, 4372.
  Mathematics should not be a *sine quâ non* for Cambridge science fellowships and scholarships, 4373.
  Intense competition for some science scholarships at Cambridge; competitors few; many scholarships not awarded for want of good competitors, 4503–4505.
  Cambridge science scholarships are mostly open scholarships; not available for university students; number sufficient; best candidates from Royal School of Mines, University College, &c., 4506–4509.
  Number of university scholarships at Cambridge insufficient, 4506.
  Trinity College offers the only science scholarship at Cambridge available for university students, 4507.
Schools.
  Well-trained pupils from public schools might enter at once on science at Cambridge, 4433, 4434, 4468–4473.
  Physics and chemistry taught in public schools would bring more science students to universities, 4451, 4452.
  Better preparation in endowed schools would increase Cambridge science students, 4466, 4467.
  Defective teaching in schools shown by Cambridge science scholarship candidates, 4505.
Science.
  The feeling in favour of natural science is growing at Cambridge University, 4391.
  Better teaching in schools would increase number of science students in universities, 4451, 4452, 4466, 4467.
  Importance of scientific knowledge to clergymen, 4513–4516, 4520–4526.
    See *Cambridge University.*
Shipbuilding.
  Shipbuilding models wanted at Cambridge University, 4395.

HUMPHRY, Professor—cont.

Sidney College (Cambridge).
Chemical laboratory at Sidney College; should be combined with others, 4436.

Students.
Practical teaching wanted for students at Cambridge University, 4358–4361, 4486–4502.
Importance to students of being employed as professors' assistants, 4365.
Ordinary degree examination at Cambridge prejudicial to undergraduates; all should prepare for honours, 4369, 4440–4443.
Highly qualified students have competed for Cambridge open science scholarships; many candidates have been unworthy, 4372, 4503–4509.
Advantage to Cambridge students of long vacation, but not of other vacations, 4380, 4381.
Approval of athletics for Cambridge students, 4382, 4383.
College life at Cambridge advantageous to students, 4383–4384.
Natural science tripos at Cambridge has about 12 candidates, chiefly medical; number will probably increase, 4389–4393.
Students mostly attend anatomy course at Cambridge with a view to degrees, 4408, 4409.
Cambridge teaching should introduce students to medicine; they should attend hospitals, 4423.
Great freedom in selection of studies desirable for Cambridge students; importance of devotion to one study, 4427–4430, 4444, 4445.
Students entering Cambridge with proper basis of knowledge, might proceed at once to science, 4431, 4468–4473.
Better preparation in endowed schools would increase science students at Cambridge, 4451, 4452, 4466, 4467.
Cambridge science students in individual colleges must be few; they would be better collected in one University school, 4465.
Not many Cambridge students enter into practical scientific professions, as a consequence of their training, 4476.
Cambridge men studying for the Church work but little at science, 4477, 4478, 4513–4526.
No examination for Cambridge students until after two or more terms, 4483–4485.
For University students at Cambridge more scholarships are wanted, 4506, 4507.

Teachers. See *Assistant Professors, &c.*

Technical Instruction.
At Cambridge University, technical subjects need not be taught, but referred to in application of pure science, 4424–4426, 4496, 4497.
In chemistry and medicine, theoretical and technical teaching are combined at Cambridge, 4497–4499.

Theology. See *Religion.*

Trinity College (Cambridge).
Fellowship, and annual scholarship, for science, given by Trinity College, 4371, 4372, 4446, 4507.
Importance of prælectorship of physiology founded by Trinity College, 4403, 4419, 4420.
Combination of Trinity and St. John's Colleges for purposes of instruction; Trinity teaching physics, 4436.
Trinity College has a matriculation examination, 4484.

University College (London).
For Cambridge open science scholarships, University College has furnished some of the best competitors, 4509.

Vacations.
Cambridge University vacations are too long, especially at Christmas; the long vacation is advantageous, 4380, 4381.

LIVEING, PROFESSOR GEORGE DOWNING, M.A.
(Index of his Evidence.)

Age of Students.
Few Cambridge students enter before 18; 21 is late to begin professional training, 4585, 4586.
Little boys might learn classificatory sciences; boys of 15, heat, chemistry, &c.; boys of 17 might compete for Cambridge open scholarships, 4603, 4604.
Candidates for Woolwich must be between 16 and 19, 4609.

LIVEING, Professor—cont.

Apparatus for Science Purposes.
Defective provision of scientific apparatus at Cambridge University, 4554–4556, 4653.
Appliances for science teaching at public schools of Rugby, Harrow, Clifton, &c., 4629, 4630.

Assistant Professors, Demonstrators, and Teachers.
Real teaching in Cambridge University has been done by college lecturers and private tutors, 4539, 4649.
Teaching of college tutors at Cambridge has been mainly mathematical, 4540.
Advantage of the Cambridge long vacation to teachers, 4546.
Sub-professors wanted at Cambridge; college tutors might become assistants to professors, under proper organization, 4549, 4650.
Difficulty of finding good teachers of science for schools, 4602.
Private science tutors at Cambridge are few, 4649.

Astronomy.
Difficult for primary school children to grasp laws of astronomy, 4618–4628.

Birmingham School.
Laboratory for science teaching at Birmingham School, 4629, 4630.

Botany.
Botany might be taught to children in primary schools, 4616, 4617.

Cambridge University.
Colleges at Cambridge; several have open science scholarships; college tutors do the real work; combination for science, &c.; professoriate should not be under colleges; parliamentary aid essential to divert college funds to University instruction, 4535–4540, 4550, 4644, 4645.
Cambridge students; with open examinations, many might go for a short time; difficulty of their getting both scientific and professional training; more science rewards for students desirable, 4535–4538, 4543–4547, 4566–4594, 4639, 4650, 4652.
Cambridge fellowships and scholarships; approval of electing professors to fellowships; students from endowed schools should be eligible for fellowships; open scholarships at several colleges, 4535–4538, 4557–4559, 4635–4641.
Science teaching at Cambridge incomplete; short time of attendance of students; insufficient professorial staff; practical instruction should be given, 4539, 4540, 4543–4556, 4568–4581, 4591–4594, 4652, 4653.
Professors at Cambridge; staff incomplete; more for chemistry wanted; approval of their election to fellowships; should be under University, not colleges, 4539, 4540, 4548, 4551–4556, 4561–4565, 4642–4653.
Assistant professors and teachers at Cambridge much wanted; college tutors might act; private science tutors are few, 4539, 4540, 4546, 4549, 4649, 4650.
Lectures at Cambridge incomplete; given at will of professor; should be subject to regulating authority, 4539, 4540, 4569–4581, 4642–4647.
Advantage of the long vacation at Cambridge, 4545–4547.
Funds at Cambridge; inadequate for payment of professors; University funds exhausted; college endowments must be diverted, 4551–4559, 4562–4564, 4650.
Want of scientific apparatus at Cambridge, 4554–4556, 4653.
Examinations at Cambridge; first examination in second term for medical and honours' men; third term for others, 4566–4568, 4583–4588, 4635–4641.
Cambridge degrees; special examination, after two general ones, for ordinary degree; pass-men and honours' men attend chemical lectures; three years' residence for degree might be waived, 4566–4588.
Want of Greek should not be an impediment to endowed schools' students at Cambridge, 4635–4641.
See *Trinity College (Cambridge).*

Cheltenham College.
Science department at Cheltenham College tolerably successful; laboratory there, 4631, 4629, 4630.
Pupils from Cheltenham College go to Woolwich examinations, 4606.
Bifurcation system adopted at Cheltenham College for some years, 4633.

Chemistry.
Larger staff for teaching chemistry wanted at Cambridge University; room for three professors, 4548, 4551–4553.

Liveing, Professor—*Chemistry*—cont.

Professor of chemistry at Cambridge has a fair laboratory, but finds his own lecture apparatus, 4555, 4556, 4653.
For Cambridge ordinary degree, chemistry is one optional subject in natural science examinations, 4568.
Chemical professors' lectures at Cambridge are attended by pass-men and honours' men; medical students attend; lectures comprise heat, 4569–4581.
Practical application of chemistry might be taught at Cambridge; separate professor requisite, 4591–4594.
Chemistry might be studied with advantage by lads of 15 years of age, 4603.
Chemistry not more liable to cram than other sciences, 4610, 4611.
Analytic and synthetic chemistry should be taught at Cambridge by different professors, 4652.

Children.
Little boys might be taught sciences of classification, 4603.
Children in primary schools could not be taught much science, 4616–4628.
Boys at Harrow, Rugby, &c., have inadequate time for science, 4631.

Clifton College.
Clifton College has a laboratory for science teaching, 4629.

Cramming.
Chemistry not more liable to cram than other sciences, 4610.
Cramming can be detected by a good examiner, 4611.

Degrees.
Candidates for Cambridge ordinary degree, after two general examinations, pass a special one; natural science or chemistry, &c., required, 4566–4568.
Pass-men attend chemical lectures at Cambridge, but honours' men chiefly; number increasing; medical students attend, 4569–4581.
Three years' residence required for degree at Cambridge; examinations free from this restriction desirable, 4583–4588.

Endowed Schools' Commission.
Approval of schools proposed by Endowed Schools' Commission, 4635–4641.

Examinations.
Competitive examinations have given impetus to science in public schools, 4531.
Examination is almost the only test in which the public have confidence, 4532–4534.
A special examination, after two general ones, has to be passed by candidates for Cambridge ordinary degree, 4566–4568.
Good would result from open examinations, without regard to residence, at Cambridge, 4583–4588.
Middle-class local examinations; little result in science; show improvement, as do Woolwich examinations, 4597–4601, 4605–4609.
Endowed schools' pupils entering Cambridge, after literary examination, might proceed with science, compete for fellowships, &c., 4635–4641.
First examination at Cambridge may occur in second term for medical students and honours' candidates; in third term for others, 4639.

Examiners.
Good examiners can detect cramming, 4611.

Fellowships.
Approval of electing Cambridge professors to fellowships, 4557–4559.
Cambridge students, from endowed schools, should be eligible for fellowships, 4635–4641.

Geography (Physical).
Little physical geography could be taught to children in primary schools, 4616–4621.

Greek.
Cambridge University should adapt itself to reception of youths taught in schools where Greek is not studied, 4635–4641.

Harrow School.
Pupils from Harrow School go to Woolwich examinations, 4606.
Harrow School has a laboratory for science teaching, 4629, 4630.
Bifurcation system adopted at Harrow School, 4633.

Heat.
Professor of chemistry at Cambridge University lectures on heat; which he should not do, 4577–4579.
Heat forms a subject in two divisions of ordinary degree examination at Cambridge, 4580.

Liveing, Professor—*Heat*—cont.

Heat might be studied with advantage by boys about 15 4603.

Honours.
Chemistry professor at Cambridge University sometimes lectures to honours' men separately; most of his students attend with view to honours, 4572–4576.
First examination of honours' candidates at Cambridge may occur in their second term, 4639.

Income and Expenditure.
Stipends of professors at Cambridge University are about 300*l.* a year; supplemented by fees, which outgoings often swallow up, 4554, 4556.
Electing Cambridge professors to fellowships is a desirable mode of increasing their income, 4557–4559.
To increase professorial staff at Cambridge, college endowments must be applied; university funds are exhausted, 4562–4564, 4650.

Laboratories.
Want of provision for requisites in laboratories at Cambridge University, 4554–4556.
Chemical professor at Cambridge has a fair laboratory; he pays for apparatus himself, 4555, 4556, 4653.
Laboratories for science instruction at Rugby, Harrow, Clifton, and other schools, 4629, 4630.

Lectures.
Courses of many professors at Cambridge University are incomplete; more complete courses to be given in future, 4539, 4540, 4642.
Chemical professors' lectures at Cambridge attended by pass men and honours' men; chiefly the latter, 4569–4581.
Professor of chemistry at Cambridge lectures also on heat, which is objectionable, 4577–4579.
Courses of lectures at Cambridge are given at professors' own will; they should be subject to some regulating authority, 4643, 4646, 4647.

Literature.
Pupils from endowed schools entering Cambridge University might pursue science on passing examination in literature, 4635–4641.

Mathematics.
Teaching of college tutors at Cambridge University has been mainly mathematical, 4540.

Medicine.
Medical students attend chemical professor's lectures at Cambridge University, 4576.
Difficulty of instructing medical students in both theory and practice, 4594.
First examination of medical students at Cambridge may occur in their second term, 4639.
Medical professor's courses at Cambridge are more complete than others, 4642.

Parliament.
Parliamentary aid essential to divert collegiate funds to University science professoriate at Cambridge, 4644, 4645.

Physics. See *Heat.*

Practical Instruction.
Approval of practical schools being attached to Cambridge University; application of chemistry might be taught, 4589–4596.
Danger of students who should be learning principles being attracted to practical applications, 4594.

Professors.
Professors at Cambridge University represent particular branches of science only; the staff is to be more complete; medical professors an exception, 4539, 4540, 4642–4647.
Larger professorial staff for teaching chemistry wanted at Cambridge, 4548, 4551, 4552, 4565.
Sub-professors wanted at Cambridge; with proper organization, college tutors might become assistants, 4549, 4650.
For catechetical teaching, a professor could take ten or a dozen students at a time, 4553.
Inadequate funds for payment of professors at Cambridge, 4554, 4556.
Chemical professor at Cambridge has a fair laboratory, but pays for lecture apparatus himself, 4555, 4556, 4653.
Approval of electing Cambridge professors to fellowships, 4557–4561.
For increasing professorial staff at Cambridge, college endowments must be applied, 4562–4564.
Professoriate at Cambridge should be under the University, not the colleges, 4644–4651.

LIVEING, Professor—cont.

Professorships.
More professorships wanted at Cambridge University, 4650.

Rugby School.
Rugby School has a laboratory for science teaching, 4629, 4630.

Salaries. See *Income.*

Scholarships.
Open scholarships for science at several colleges at Cambridge University, 4535–4537.
Cambridge students tolerably proficient in science would probably obtain a scholarship, 4538.
With good teaching in schools, boys of 17 might compete for Cambridge open scholarships, 4604.
Cambridge students, from endowed schools, after first examination, should be eligible for scholarships, 4635–4641.

Schools.
Small results hitherto from science teaching in public schools; uncertainty of masters as to subjects; difficulty of finding teachers, 4527–4530, 4602.
Competitive examinations have given an impetus to science in public schools, 4531.
Incentives to retaining promising pupils in schools, 4586.
Boys in school might learn classificatory sciences; at about 15 years, might study heat, chemistry, &c.; about 17, might compete for Cambridge open scholarships, 4603, 4604.
Woolwich candidates come from various public schools; late examinations show improvement, 4605–4609.
Little science could be taught in primary schools, 4616–4628.
Laboratories, &c., for science instruction, in schools of Rugby, Clifton, Harrow, &c., 4629, 4630.
Inadequate time allowed for science in public schools, 4631.
In most public schools the classical and scientific departments are separate; scheme successful, but science masters complain of getting the idlest boys, 4632–4634.
Cambridge University should adapt itself to reception of youths from schools proposed by Endowed Schools' Commission, 4635–4641.

Science.
Science teaching in public schools; not much result yet; laboratories at Harrow, Rugby, &c.; inadequate time given to science; bifurcation in most schools, 4527–4531, 4629–4634.
Advantage of working at science in conjunction with other studies, 4541, 4542.
Danger of students, who should study principles of science, being attracted to practical applications, 4594.
Not much science shown by middle-class local examinations, 4597–4601.
Heads of schools do not understand what science should be taught to boys, 4602.
Sciences of classification might be taught to young boys; heat, chemistry, &c. to those of 15; about 17 they might compete for open scholarships at Cambridge, 4603, 4604.
Imperfect knowledge of science shown by the Woolwich candidates; they are improving, 4605–4609.
Little science could be taught to children in primary schools, 4616–4618.
See *Cambridge University.*

Students.
Candidates for Cambridge open science scholarships are sometimes good, but sometimes very bad, 4536–4537.
Cambridge students tolerably proficient in science would probably obtain a scholarship, 4538.
Students at Cambridge [illegible], 4543, 4544.
Advantage of the long vacation to Cambridge students, 4545–4547.
Advantage to students of working at science in conjunction with other studies, 4541, 4542.
For [illegible] might take 10 or 12 students, [illegible].
Ordinary degree course at Cambridge, after two general examinations, [illegible], 4566–4568.
Chemical lectures at Cambridge attended by pass-men, but mostly by honours' men, and by medical students, 4569–[illegible].
With open examination at Cambridge, many students would go for a short time with advantage, [illegible] 4588.
Difficulty of Cambridge students getting both scientific and professional training; mostly enter university too late, 4584–4588.

LIVEING, Professor—*Students*—cont.
Practical schools desirable in Cambridge University; but students, who should be learning principles, are in danger of being attracted to applications, 4589–4594.
Candidates at middle-class local examinations have not done much in science; improvement shown, 4597–4601.
Little boys may be taught classificatory sciences; chemistry, heat, &c. at 15; at 17 might compete for Cambridge open scholarships, 4602–4604.
Deficiency in science of Woolwich candidates; they are improving, 4604–4609.
Endowed schools' students, entering Cambridge, should be allowed to study science on passing literary examination, 4635–4641.
First examination for medical students or honours' candidates at Cambridge may occur in their second term; third term for others, 4,639.
More rewards for science students wanted at Cambridge, 4650.
Students of analytical chemistry require some one always at hand, 4652.

Teachers. See *Assistant Professors, &c.*

Trinity College (Cambridge).
Election of a professor to a fellowship at Trinity College, 4559.
Trinity College is eccentric in regard to time of assembling and breaking up, 4613.

Vacation.
Advantage of Cambridge long vacation to teachers and students, 4545–4547.

Wellington College.
Pupils from Wellington College attend Woolwich examinations, 4106.

Woolwich.
Candidates for Woolwich have shown imperfect knowledge of science, but they are improving, 4604–4609.

Zoology.
Zoology might be taught to children in primary schools, 4616.

WILLIS, Rev. R., M.A. (Index of his Evidence.)

Accommodation for Science Purposes.
Good lecture rooms, &c., for teaching mechanism, at Cambridge University, 4664.
For science teaching, Cambridge University has provided some buildings, with laboratories, &c.; similar provision should be made for every science, 4694–4698.

Anatomy.
Jacksonian professor of philosophy at Cambridge is required to be skilled in anatomy, 4655, 4656.

Apparatus for Science Purposes.
Apparatus for teaching mechanism at Cambridge University is paid for by lecturer; should be provided by University; but the apparatus could not be more efficient than it is, 4659, 4670, 4671, 4690–4698.
Lectures on architecture at Cambridge, illustrated by an original system of modelling, 4676.
Cambridge University should provide apparatus for teaching every science efficiently, 4692–4698.

Archæology.
Great interest taken by Cambridge students in archæology, 4674.

Architecture.
Lectures on architecture, illustrated by original models, at Cambridge University; great interest taken in the subject by students, 4673–4676.

Assistant Professors, Demonstrators, &c.
A demonstrator assists Jacksonian professor at Cambridge University; he is paid by the professor, 4671, 4672.

Cambridge University.
Jacksonian professor of natural and experimental philosophy at Cambridge; his duties ill defined; knowledge of anatomy essential; lectures on mechanism, and also on architecture, and pays for his illustrations himself; has a large class, 4654–4699.
Lectures at Cambridge; mechanism and architecture; popularity of Professor Farish's lectures formerly, 4657–4676, 4690–4698.
Fees at Cambridge are divided among the lecturing professors, 4660, 4661.
Buildings and apparatus for science teaching at Cambridge; some provided; but University should make similar provision for every science, 4659, 4664, 4670, 4671, 4676, 4692–4698.

Willis, Rev. R.—*Cambridge University*—cont.

Cambridge students; take great interest in mechanism, architecture, and archæology; should be taught principles, not technical details, 4660–4669, 4674, 4678–4689.

Examination at Cambridge follows the lectures on mechanism; it is not conducted by lecturer, 4661–4665.

Degrees at Cambridge; all candidates must attend lectures of certain professors, 4660 4665, 4685.

Scientific education at Cambridge is abstract and theoretical, 4689.

Degrees.

Candidates for degrees at Cambridge University must attend lectures of certain professors, 4660, 4685.

Students attending lectures on mechanism at Cambridge with a view to degrees have a final examination, 4661–4665.

Education.

Education at Cambridge University with respect to science is abstract and theoretical, 4689.

Engineering.

Some Cambridge students, after attending lectures on mechanism, have gone into engineering, 4663, 4669.

Examinations.

Final examination for a degree follows lectures on mechanism at Cambridge University; examination not conducted by lecturer, 4661–4665.

Farish, Professor.

Popularity of Professor Farish's lectures on mechanism formerly given at Cambridge University; the illustrations were paid for by himself, 4657, 4668, 4690.

Fees. See *Income, &c.*

Income and Expenditure.

300*l.* per annum and share of fees form stipend of Jacksonian professor at Cambridge University, 4660.

Fees at Cambridge; collected by cards purchased at registrar's office; divided among lecturing professors, 4660, 4661.

University funds at Cambridge should be applied to buildings and apparatus for developing science, 4696, 4697.

Jacksonian Professor. See *Cambridge University.*

King's College (London).

Workshops for mechanical instruction at King's College, London, 4680.

Laboratories.

Buildings containing laboratories have been provided at Cambridge University, 4694.

Lectures.

Lectures on principles of mechanism at Cambridge University; final examination for degree; large class; illustrations (which lecturer pays for) could not be more efficient, 4657–4672, 4681–4698.

Professor Farish's lectures on mechanism formerly given at Cambridge were very popular, 4657, 4668.

Certain professors' lectures at Cambridge must be attended by all candidates for degrees, 4660.

Lectures on architecture, illustrated by an original system of modelling, at Cambridge, 4673–4676.

Mathematics.

Only the ordinary forms of mathematics are essential for attending lectures on mechanism at Cambridge University, 4658.

Mechanism.

Principles of mechanism taught at Cambridge University; machinery exhibited; apparatus efficient, 4654–4672.

Popularity of Professor Farish's lectures on mechanism formerly given at Cambridge; working models were paid for by himself, 4657, 4668, 4690.

At Cambridge University, principles of mechanism, not technical details, should be taught, 4678–4689.

Practical Instruction. See *Technical Instruction.*

Professors.

Jacksonian professor of natural and experimental philosophy at Cambridge; he is required to know anatomy; lectures on mechanism and architecture, 4654–4699.

Courses of certain professors must be attended by students at Cambridge University who wish to take degrees, 4660, 4685.

Science.

Scientific education at Cambridge University; it is abstract and theoretical; University funds should be applied to buildings, &c. for science, 4689, 4696, 4697.

Willis, Rev. R.—cont.

Students.

Students of mechanism at Cambridge University; large mixed class; take great interest; some have gone into engineering, 4660–4669.

All Cambridge students, before taking a degree, must attend courses of one or more professors, 4660, 4685.

Great interest taken by Cambridge students in architecture and archæology, 4674.

Cambridge students should be taught principles of science, not technical details, 4678–4689.

Technical Instruction.

Undesirable to give technical instruction at Cambridge University, 4678–4689.

King's College, London, has workshops for giving technical instruction, 4680.

NEWTON, Professor ALFRED, M.A. (Index of his Evidence.)

Accommodation for Science Purposes.

Cambridge University museums of zoology, anatomy, chemistry, botany, and mineralogy are supported by annual vote, 4702–4715, 4740–4745, 4794–4798, 4808–4812.

Dissecting-room for comparative anatomy wanted at Cambridge; more room for students requisite, 4764–4766, 4794–4802.

Accommodation, &c., for teaching anatomy at Cambridge would require double the present allotted sum, 4810–4812.

Anatomy.

Museums of zoology and comparative anatomy at Cambridge University; curator wanted, 4702–4715, 4735, 4736, 4740–4745.

Anatomy and zoology instruction at Cambridge; separate professors desirable; a professor of comparative anatomy might go more deeply into the subject, 4746–4755, 4761–4774.

Cambridge students do practical work in comparative anatomy, but want more convenience, 4764, 4794–4802.

Demonstrator of anatomy required at Cambridge; present officer paid for by Mr. Clark, 4807.

Assistant Professor, Demonstrators, &c.

Demonstrator of anatomy and curator of museum should be appointed at Cambridge; present demonstrator is paid by Mr. Clark, 4708, 4714, 4807–4809.

Cambridge men studying for teachers of science will be more numerous when endowed schools teach science, 4776.

College officers at Cambridge are well paid, 4791.

New prælector in physiology at Trinity College, Cambridge; his teaching is distinct from that of the University professor of zoology, 4813, 4814.

Botany.

Museum of botany at Cambridge is supported by annual vote of University, 4707.

Cambridge University.

Zoology and anatomy instruction at Cambridge University, 4700–4818.

Professors at Cambridge; professor of zoology and anatomy; separate professors for these subjects desirable; stipends should be increased; multiplication of professors would promote research, 4700, 4701, 4730–4731, 4737–4739, 4746–4755, 4761–4774, 4778–4781, 4786–4802.

Buildings for science purposes at Cambridge; museums; dissecting-room wanted; more accommodation for students required; double present expenditure needed to provide for anatomical teaching, 4702–4715, 4740–4745, 4674–4766, 4794–4798, 4808–4812.

Funds of Cambridge; inadequate salaries of professors, demonstrators, &c.; grants for science very insufficient; incomes of fellowships are not too large; college officers are well paid, 4708–4726, 4737–4739, 4775, 4786–4791.

Assistant professors, &c., at Cambridge; demonstrator of anatomy and curator wanted; new prælector in physiology at Trinity College, 4708, 4714, 4776, 4791, 4807–4809, 4813, 4814.

Colleges at Cambridge; should offer more rewards for natural science; heads of colleges should not be abolished; objections of many colleges to elect to natural science fellowships; should contribute to University professoriate; external pressure on colleges might be desirable; college offices might be reduced; college officers are well paid, 4719–4729, 4757, 4758, 4782–4791, 4817.

NEWTON, Professor—*Cambridge University*—cont.
  Cambridge students; zoology and anatomy students; more college rewards should be offered to students, 4747–4752, 4757–4760, 4764–4774, 4792–4806.
  Degrees at Cambridge; few ordinary degree men at zoology and anatomy lectures, 4747–4752, 4773, 4774.
  Cambridge fellowships and scholarships; objection of many colleges to award them; should not be specially connected with natural science; emoluments or duration of fellowships should not be lessened, 4756, 4782–4784, 4789.

Chemistry.
  Museum of chemistry at Cambridge is supported by annual vote of University, 4707.

Cost, Income, &c.
  Museums at Cambridge University are allowed 1,000*l*. a year for building fund and 1,500*l*. a year maintenance; double the amount wanted, 4707–4715.
  Inadequate salaries of superintendent, demonstrator, &c., of zoology and anatomy museums at Cambridge University, 4708–4715.
  Private subscriptions (including college contributions) for fittings for zoological museum at Cambridge; 1,005*l*. subscribed in four years, 4711, 4775.
  Funds for science purposes at Cambridge University are wholly inadequate; increase might come from colleges, 4716–4726, 4786–4791.
  Professor of zoology and anatomy at Cambridge receives 300*l*. a year, 4737, 4738.
  Stipends of Cambridge professors should be increased, 4739.
  Incomes of Cambridge fellowships are not too large, 4789.
  College officers at Cambridge are well paid, 4791.

Curators. See under *Assistant Professors, &c.*

Degrees.
  Few ordinary degree candidates attend the lectures on zoology and anatomy at Cambridge; certificates of such attendance essential where candidates choose zoology, 4747–4752, 4773, 4774.

Fellowships and Scholarships.
  Cambridge fellowships and scholarships have been awarded where zoology and anatomy formed subjects of examination, but not specially for those subjects, 4756.
  Objection of many colleges at Cambridge to elect to natural science fellowships, 4782, 4783.
  Undesirable to connect Cambridge fellowships specially with natural science, 4784.
  Objection to lessening emoluments or duration of Cambridge fellowships, 4789.

Heads of Colleges.
  Objection to abolition of heads of colleges at Cambridge; they might well perform some duties, 4727–4729.

Honours.
  Zoology and anatomy lectures at Cambridge University are attended by men working for honours in natural sciences' tripos, 4752.

Lectures.
  Lectures on zoology and anatomy at Cambridge University; number of students increasing; obligatory for medical course; they might be given by separate professors; more accommodation wanted, 4746–4755, 4761–4774, 4793–4802.

Literature.
  Classical knowledge necessary for every man of science, 4758, 4759.

Mathematics.
  All scientific men should have mathematical knowledge, 4758, 4759.

Medicine.
  Cambridge University zoology and anatomy lectures are attended by a large number of medical students; course obligatory for them, 4748, 4751, 4767, 4793.

Mineralogy.
  Museum of mineralogy at Cambridge is supported by annual vote of University, 4707.

Museums. See *Cambridge University.*

Original Research.
  Original research would be promoted at Cambridge University by multiplication of professorships, 4777–4781.

Parliament.
  Pressure of public opinion on colleges at Cambridge would be better than actual legislation, 4719–4726, 4786–4791.

NEWTON, Professor—cont.

Physiology.
  New prælector of Trinity College, Cambridge, lectures on physiology; teaching distinct from University, 4813, 4814.

Practical Instruction.
  Cambridge students of comparative anatomy engage in practical work; deficient accommodation for them, 4764, 4794–4802.

Prælectors. See under *Assistant Professors, &c.*

Professors.
  Professor of zoology and comparative anatomy in Cambridge University; receives 300*l*. a year; separate professors desirable, 4700, 4701, 4737, 4738, 4746–4755, 4761–4771, 4793–4802.
  Stipends of Cambridge professors should be increased, 4739.
  Professoriate at Cambridge might receive support from the colleges; college offices might be diminished in number for this purpose, 4786–4791.

Professorships.
  Attachment of professorships to fellowships; they are not permanently attached, 4730–4734.
  Multiplication of professorships at Cambridge would promote original research, 4777–4781.

Salaries. See *Cost, Income, &c.*

Scholarships. See *Fellowships and Scholarships.*

Schools.
  Science teaching in endowed schools would increase number of Cambridge men studying for teachers, 4771.

Science.
  Classical and mathematical knowledge essential for every man of science, 4758, 4759.
  Science chiefly advanced by those who work for its own sake, and not for pay, 4760.
    See *Cambridge University.*

Students.
  Cambridge students of zoology and anatomy; mostly medical students; number increasing; do practical work, but want accommodation, 4747–4752, 4764–4774, 4792, 4806.
  Cambridge natural science students should have more college honours and emoluments awarded them, 4757, 4758, 4760.
  Science instruction in endowed schools would increase number of Cambridge students desirous of becoming teachers, 4771.

Trinity College (Cambridge).
  Lectures on physiology at Trinity College, Cambridge, by new prælector, 4813, 4814.

Zoology. See under *Anatomy.*

BATESON, REV. WILLIAM H., D.D. (Index of his Evidence.)

Accommodation for Science Purposes.
  Museums, &c. might be provided by University of Cambridge, if it were relieved from professors' salaries, 4955, 4972–4975.

Assistant Professors and Teachers.
  Collegiate funds might go to augment sub-professors' salaries at Cambridge University, 4955.
  Teachers of inferior class to professors are always essential at Cambridge, 4959.

Cambridge University.
  Colleges at Cambridge; a per-centage or a definite sum from college funds should be devoted to University instruction; legislative aid necessary to effect this; objection of many colleges to taxation; the combination established will probably spread; alteration of college fellowships desirable, 4946–4993.
  Science teaching at Cambridge; measures to promote science for some years past; great efforts now being made; syndicate to consider institution of professorship in physical science, 4949, 4950, 4981–4984.
  Funds at Cambridge; University should have about 10,000*l*. a year from colleges; salaries of professors should be increased, 4949–4953, 4969–4976.
  Professors at Cambridge; should have 800*l*. a year; should not do ordinary work of University; they are represented in governing body of University, 4950, 4955–4959, 4977–4980.
  University could provide museums, &c. if relieved from payment of professors, 4955, 4972–4975.
  Cambridge examinations; professorial instruction not essential for ordinary examinations; pass examinations do not show much love of science, 4959, 4974, 4983.

Bateson, Rev. W. H.—*Cambridge University*—cont.
  Students at Cambridge; professorial instruction not essential for ordinary students; many students work simply from love of knowledge, 4959, 4984.
  Cambridge fellowships; might be diminished, tenure altered, and marriage allowed; science fellowships are given for merit, and are as likely to be attained as others, 4963–4968, 4987, 4988.
    See *Saint John's College* (*Cambridge*).

Chemistry.
  Chemical laboratory in active operation for nearly 20 years at St. John's College, Cambridge, 4985, 4989, 4990.

Examinations.
  Professorial instruction not adapted to prepare for ordinary examinations at Cambridge, 4959.
  Cambridge University, if relieved from professors' salaries, could provide for examinations, &c., 4974.
  Pass examinations at Cambridge do not show much love of science, 4983.

Fellowships.
  Cambridge fellowships; diminution in number might be effected; tenure might be altered, and fellows allowed to marry, 4963–4968.
  Holders of St. John's College fellowships could not be compelled to reside and teach in the University, 4969.
  Fellowships in science, equally with those in other subjects, would be given solely for merit at Cambridge, 4987, 4988.

Geology.
  Lectureship in geology established two or three years back at St. John's College, Cambridge, 4985.

Income and Expenditure.
  About 10,000*l.* a year of college funds should be devoted to University instruction, 4949–4952, 4969–4971, 4976.
  Income of colleges at Cambridge has been estimated at 180,000*l.*, 4953.
  Collegiate funds should go to increase salaries of Cambridge professors; they should have 800*l.* a year, 4955–4958.
  If relieved from professors' salaries, Cambridge University could provide for museums and examinations, &c., 4955, 4972–4975.
  Objection to taxation for University purposes of many colleges at Cambridge, 4960–4962.

Laboratories.
  Chemical laboratory nearly 20 years in active operation at St. John's College, Cambridge, 4985, 4989, 4990.

Lectures.
  Lectures on geology at St. John's College, Cambridge, 4985.

Marriage of Fellows.
  System of Cambridge fellowships, with liberty to marry, has worked well, 4967.

Parliament.
  Desirability of legislative enactment for devoting collegiate funds to University teaching at Cambridge, 4949–4951, 4969–4971.

Physics.
  Syndicate at Cambridge to consider institution of a professorship in physical science, 4950.

Professors.
  Collegiate funds at Cambridge should go to increase salaries of professors; they should have 800*l.* a year, 4955–4958.
  Professorial instruction not adapted to ordinary University work at Cambridge; inferior teachers should do this, 4959.
  Representation of the professoriate at Cambridge exists at present; it would become more desirable with the growth of the school, 4977–4980.

Professorships.
  Syndicate at Cambridge University to consider the institution of a professorship in physical science, 4950.

Saint John's College (*Cambridge*).
  Non-resident fellows of St. John's College could not be compelled to reside and teach in University, 4968.
  Chemical laboratory in active operation for nearly 20 years at St. John's College; students from other colleges admitted, 4985, 4989, 4990.
  Lectureship in geology established two or three years ago at St. John's College, 4985.
  Fellowships in science, equally with those in other subjects, would be given solely for merit at St. John's College, 4987.

Bateson, Rev. W. H.—cont.

Salaries. See *Income, &c.*

Students.
  Professorial instruction not essential for preparing ordinary students at Cambridge, 4959.
  Many students work at Cambridge simply from love of knowledge; several have had one year's instruction for that purpose, 4984.

THOMPSON, Rev. WILLIAM HEPWORTH, D.D.
(Index of his Evidence.)

Accommodation for Science Purposes.
  Lecture room recently fitted up at Trinity College, Cambridge, for physical science teaching, 4996.

Apparatus for Science Purposes.
  Apparatus for physical science teaching at Trinity College, Cambridge, 4996.

Cambridge University.
  Cambridge University has exerted itself as much as possible to promote science, 4999.
  Colleges at Cambridge; collegiate funds should be contributed to University purposes; all the colleges not likely to agree to the contribution, 4999–5011.
  Funds at Cambridge; additional funds for University wanted; five per cent. of college income should be appropriated to University; fund should be managed by a permanent committee composed of professors, persons of financial ability, &c., 4999–5011, 5017–5019.
  Cambridge professors; collegiate funds should go to assist existing and to provide additional professors, 5003.
  Museum, apparatus, &c., should be provided at Cambridge from collegiate funds, 5003.
  Literature is insufficiently represented at Cambridge, 5003.
  Greek formerly considered the most advanced study at Cambridge, 5014.
  Cambridge fellowships; desirability of connecting them with professorships, 5012–5016, 5028.
  Cambridge students; increase of medical students; a certain number of science students study to become teachers, 4998, 5020–5023.
    See *Trinity College* (*Cambridge*).

Education.
  Desirability of general University training for scientific men, 5023.

Examinations.
  Special examination at Trinity College, Cambridge, for natural science fellowships, 5024.

Fellowships.
  Approval of Cambridge fellowships being connected with professorships, 5012–5016, 5028.
  Natural science fellowships at Trinity College, Cambridge; given occasionally; special examination instituted, 5024–5028.

Foster, Dr. Michael.
  Appointed to prælectorship in physiology founded by Trinity College, Cambridge, 4996–4998, 5020.

Greek.
  Teaching of Greek at Cambridge University; formerly considered the most advanced of all studies, 5014.

Income.
  Prælector in physiology at Trinity College, Cambridge, has about 600*l.* a year, 4997.
  Cambridge University income; its means limited; additional funds wanted; should have five per cent. of collegiate income, 4999–5011.

Laboratory.
  Laboratory instruction given by prælector in physiology at Trinity College, Cambridge, 5020.

Lectures.
  Physical science lectures instituted at Trinity College, Cambridge; lectures are on heat and electricity; students from other colleges can attend, 4996.
  Lectures on physiology at Trinity College, Cambridge, are well attended, 4996–4998, 5020.

Literature.
  Literature is insufficiently represented at Cambridge University, 5003.

Medicine.
  Increasing number of medical students at Cambridge; they attend the lectures on physiology at Trinity College, 4997, 4998.

Thompson, Rev. W. H.—cont.

Physics.
- Appointment of a physical science lecturer at Trinity College, Cambridge; his lectures are on heat and electricity, 4996.

Physiology.
- Prælectorship in physiology founded at Trinity College, Cambridge, 4996–4998, 5020.

Practical Instruction.
- Practical laboratory instruction in physiology given at Trinity College, Cambridge, 5020.

Professors.
- Collegiate funds at Cambridge should go to assist existing professors, and provide additional ones, 5003.
- In a permanent syndicate for management of collegiate funds, professors should be represented, 5007, 5017–5019.

Professorships.
- Desirability of connecting Cambridge fellowships with professorships, 5012–5016.

Scholarships.
- Natural science scholarships given annually by Trinity College, Cambridge; open to both Universities, 5024–5027.

Science.
- Promotion of science by Trinity College, Cambridge, 4994–5029.
- Scientific men should have had general University training, 5023.

Students.
- Cambridge medical students; increasing in number; attend the lectures on physiology at Trinity College, 4996–4998, 5020.
- Physical science lectures at Trinity College, Cambridge, are open to students from other colleges, 4996.
- A certain number of Cambridge science students work to become teachers, 5020–5023.
- Advantage of general University training for scientific men, 5023.
- Students of both Universities can compete for natural science scholarships at Trinity College, Cambridge, 5024.

Trinity College (Cambridge).
- Promotion of science at Trinity College, 4994–5029.
- Prælectorship in pure physiology founded by Trinity College; lectures well attended; medical students go to them; practical instruction in laboratory given by prælector, 4996–4998, 5020.
- Lectureship in physical science founded by Trinity College; lecture room and apparatus provided, 4996.
- Trinity College would agree to a tax of five per cent. for University purposes, if other colleges were willing, 5008.
- Approval of Trinity College fellowships being connected with University professorships, 5014.
- Natural science scholarships at Trinity College; given annually; open to both Universities, 5024–5027.
- Fellowships for natural science at Trinity College; given occasionally; special examination for them, 5024–5028.

TROTTER, Rev. COUTTS, M.A. (Index of his Evidence.)

Accommodation for Science Purposes.
- Great improvement effected in the museums and laboratories at Cambridge University, 5041.
  See *Laboratories.*

Anatomy.
- Professor of comparative anatomy is the only new natural science professor at Cambridge, 5042.

Apparatus for Science Purposes.
- Apparatus of lecturer on natural science at Trinity College, Cambridge, belongs chiefly to himself; more apparatus desirable, 5068–5070.

Assistant Professors, Demonstrators, and Teachers.
- Removal of celibacy restriction on college lecturers desirable, 5044.
- Tutors, assistant tutors, &c., at Trinity College, Cambridge, are not required to take orders, 5048.
- Demonstrator for physics' instruction wanted at Trinity College, Cambridge, 5072–5074.
- Demonstrators and assistants essential for new professor of experimental physics at Cambridge, 5075–5077.
- No demonstrator in University chemical laboratory at Cambridge; one proposed; students should have a demonstrator always at hand, 5086–5089.
- A small portion of Cambridge students study for teachers, 5099.

Trotter, Rev. C.—cont.

Botany.
- Combination of Sidney and Trinity Colleges, Cambridge, for teaching botany, 5081.

Cambridge University.
- Growing demand for natural science teaching in Cambridge University, 5033.
- Examinations at Cambridge; new science examinations instituted; special examinations for ordinary degree; college fellowships decided by result of University tripos examinations, 5033–5036, 5063–5067, 5101.
- Cambridge University has effected great improvement in the museums and laboratories; better laboratories (especially chemical) wanted; laboratories should be university rather than collegiate; physical laboratory to be instituted, 5041, 5050–5053, 5068–5073, 5070, 5071, 5086–5089.
- Cambridge students; only a few go out in natural science tripos; a small portion study for teachers; natural science tripos candidates are chiefly medical students, 5035–5038, 5081, 5089, 5099.
- Cambridge professors; new professors appointed of late; professor of comparative anatomy the only new natural science professor; professors are exempt from celibacy restriction; experimental physics' professor to be appointed, 5042–5049, 5070, 5075–5077.
- Fellowships at Cambridge; examinations for fellowships could not be dispensed with; college fellowships given on result of University tripos examination, 5047, 5064–5067.
- Funds at Cambridge; more funds urgently wanted; colleges should be taxed; funds appropriated to experimental physics, 5047, 5054–5062, 5071.
- Colleges at Cambridge; tutors, &c., not required to take orders; small college laboratories a mistake; colleges should be taxed; the feeling in favour of college taxation is gaining ground; combination of colleges for teaching, 5048, 5053–5062, 5067, 5081.
- Cambridge degrees; more posts should be obtainable by work done after taking degrees, 5065.
- Teaching of physics at Cambridge; professor of experimental physics to be appointed, and laboratory instituted; special physics' course for mathematical tripos, 5068–5085, 5090–5097.
- Demonstrators, &c., at Cambridge; tutors not required to take orders; demonstrators for physics wanted at Cambridge, 5048, 5072–5077.
- Mathematics at Cambridge; new system of mathematical tripos; high mathematics excluded from natural science tripos, 5084, 5090–5097.
- Science at Cambridge University will be most furthered by those who have educational work to do, 5098.
  See *Trinity College (Cambridge).*

Chancellor of Cambridge University.
- Physical laboratory to be instituted at Cambridge University, through the munificence of the Chancellor, 5070, 5071.

Chemistry.
- Chemical laboratory at Cambridge University requires great improvement, 5051.
- Combination of St. John's and Trinity Colleges, Cambridge, for chemical instruction, 5081.
- Chemical laboratory at Cambridge University; consists of one professor and working assistant; demonstrator proposed; room for 36 students, 5086–5089.
- Men working at practical chemistry should always have at hand some one to consult, 5089.

Degrees.
- Trinity College, Cambridge, natural science lectureship established partly in view of special examinations for ordinary degree, 5034–5036.
- More posts at Cambridge should be obtainable by work done after taking a degree, 5065.

Electricity. See *Physics.*

Examinations.
- Cambridge examinations; the new science examinations necessitated increased teaching in colleges, 5033–5036.
- Examinations (especially competitive) not a test of original power, 5064, 5101.
- For fellowships, examinations could not be done away with; candidates should send in published papers, &c., 5065, 5066.
- College fellowships at Cambridge, are given according to result of University tripos examinations, 5067.

Fellowships.
- To support of University professors devoted to science, fellowship fund might be appropriated, 5047.
- Examinations for fellowships could not be dispensed with; candidates should show original power, 5064–5066

Trotter, Rev. C.—*Fellowships*—cont.

- At Cambridge, college fellowships are given according to result of University tripos examination, 5067.

Foster, Dr. Michael. See *Prælectors.*

Geology.

- Instruction in geology at St. John's College, Cambridge; attended by Trinity College men, 5081.

Heat. See *Physics.*

Honours.

- Natural science lectures at Trinity College, Cambridge, are chiefly attended by honours' men, 5037, 5083.

Income and Expenditure.

- Fellowship fund might be appropriated to support of professors devoted to science in universities, 5047.
- Cambridge University funds; more funds urgently wanted; colleges should be taxed by some representative body; parliamentary aid probably necessary, 5054–5062.
- Funds have been appropriated for an experimental physics' laboratory at Cambridge University, 5071.

Laboratories.

- Better laboratories wanted at Cambridge University, 5050, 5051.
- Multiplication of small laboratories in colleges at Cambridge is a mistake, 5052, 5053.
- University rather than collegiate laboratories desirable at Cambridge, 5053.
- Physical laboratory to be instituted at Cambridge, through munificence of Chancellor, 5070, 5071.
- University chemical laboratory at Cambridge; room for 36 students; demonstrator wanted; one proposed, 5086–5089.

Lectures.

- Lectureship in natural science at Trinity College, Cambridge; classes small; chiefly of honours' men, 5030–5038, 5068–5085.
- Celibacy restriction on college lectureships should be removed, 5043, 5049.
- Combination for lecture purposes of Trinity with St. John's and Sidney Colleges, Cambridge, 5081.
- Special lectures at Trinity College, Cambridge, for passmen, natural science tripos, and mathematical tripos, 5084, 5085, 5090–5097.

Lecturers. See *Assistant Professors, &c.*

Marriage.

- Celibacy restriction on college lectureships objectionable; University professors and certain other persons are exempt from the restriction, but not college lecturers, 5043, 5049.

Mathematics.

- Physics' lectures at Trinity College, Cambridge, are attended by some men wanting in mathematics, 5084.
- New system of mathematical tripos at Cambridge; special lectures to be given, 5084, 5085, 5090–5097.
- High mathematics are excluded from natural science tripos at Cambridge, 5095.
- Want of mathematical preparation is a drawback to candidates for natural sciences tripos in physics at Cambridge, 5095–5097.

Medical.

- Medical students form majority of natural science tripos candidates at Cambridge, 5099.

Original Research.

- In science examinations at Cambridge, candidates should be encouraged to send in any evidence of their power of doing original work, 5064, 5065.

Parliament.

- Act of Parliament probably necessary to carry out college taxation at Cambridge, 5060.

Physics.

- Instruction in physics (chiefly heat and electricity) at Trinity College, Cambridge; more apparatus and a laboratory wanted, 5030–5038, 5068–5085.
- Professor of experimental physics proposed to be appointed at Cambridge University, 5070.
- Physical laboratory to be instituted at Cambridge University, through munificence of Chancellor, 5070, 5071.
- Special lectures on physics in view of mathematical tripos at Cambridge University, 5084, 5085.
- Want of mathematical preparation is a drawback to candidates for natural sciences' tripos at Cambridge, 5095–5097.

Physiology. See *Prælectors.*

Prælectors.

- Successful teaching of new prælector in physiology (Dr. Michael Foster) at Trinity College, Cambridge, 5039, 5040, 5078, 5079.

Trotter, Rev. C.—*Prælectors*—cont.

- Prælectors at Cambridge are exempt from celibacy restriction, 5049.

Professors.

- New professors appointed of late at Cambridge University; professor of comparative anatomy the only new natural science professor, 5042.
- Professors devoted to science should have positions in universities which would enable them to live properly, 5043–5049.
- University professors at Cambridge are exempt from celibacy restriction, 5049.
- Professor of experimental physics to be appointed at Cambridge; demonstrators and assistants will also be essential, 5070, 5075–5077.

Religion.

- Necessity of taking orders at Cambridge University impedes progress of science, 5044.
- Trinity College, Cambridge, can dispense with condition of taking orders; tutors, assistant tutors, bursars, &c., exempt, 5048.

Saint John's College (Cambridge).

- Combination for lecture purposes of St. John's and Trinity Colleges, Cambridge, 5081.

Science.

- Promotion of science in Universities; posts should be provided for men devoted to science; celibacy restriction should be abolished; necessity of taking orders is an impediment to science, 5043–5049.
  See *Cambridge University.*

Sidney College (Cambridge).

- Combination of Sidney with Trinity College, Cambridge, for lecture purposes, 5081.

Students.

- Trinity College, Cambridge, natural science lectures open to all students of college; chiefly attended by honours' men; number attending not large, 5035–5038, 5082.
- Candidates in Cambridge science examinations should be encouraged to send in any evidence of their power of doing original work, 5064, 5065.
- Combination of Trinity with other colleges at Cambridge for instruction of students, 5081.
- Want of mathematical knowledge in Cambridge students, 5084, 5095–5097.
- Thirty-six students too many for one professor without a demonstrator, 5089.
- A small portion of Cambridge students study for teachers, 5099.
- Most natural science tripos candidates at Cambridge are medical students, 5099.
- High place in Cambridge natural science tripos not of itself proof of high ability, 5101.

Teachers. See *Assistant Professors, &c.*

Trinity College (Cambridge).

- Natural science lectures at Trinity College, Cambridge; special lectures for mathematical tripos, 5030–5038, 5043, 5049, 5068–5085, 5090–5097.
- Trinity College students; chiefly honours' men who attend natural science lectures, 5035–5038.
- Prælector in physiology appointed by Trinity College; success of his teaching, 5039, 5040, 5078, 5079.
- Tutors, assistant tutors, &c., are not required to take orders at Trinity College, 5048.
- Trinity College bound to pay 5 per cent. of income to University when other colleges do the same, 5057, 5062.
- Combination of Trinity with St. John's and Sidney Colleges for teaching purposes, 5081.

Universities.

- Promotion of science in Universities; posts wanted for men devoted to science; celibacy restriction should be removed, 5043–5049.
  See *Cambridge University, &c.*

COOKSON, Rev. HENRY WILKINSON, D.D. (Index of his Evidence.)

Accommodation for Science Purposes.

- Erection of museums and lecture-rooms for scientific instruction at Cambridge University; buildings efficient as far as they go, but they require extension, 5108.
- Excellence of museums of geology, mineralogy, botany, anatomy, and zoology, at Cambridge, 5108.
- Museums, &c. at Cambridge should be paid for from the University chest, 5167.
  See *Laboratories.*

Cookson, Rev. H. W.—cont.

Anatomy.
- Cambridge University museums of comparative and human anatomy are excellent, 5108.
- Professorship of anatomy at Cambridge University made permanent, and demonstrator appointed, in 1866, 5108.
- Anatomy an optional subject of examination for natural science scholarships at Cambridge, 5157.

Apparatus for Science Purposes.
- Apparatus for physical teaching to be provided at Cambridge University, 5108.
- Better and cheaper apparatus could be provided at Cambridge by University than by colleges separately, 5109.

Assistant Professors, Demonstrators, and Teachers.
- Appointment of demonstrators of chemistry and anatomy at Cambridge University, 5108.
- Good teachers for science schools in industrial centres might be furnished by the Universities, 5129, 5131.
- Large number of fellowships at Cambridge desirable, with a view to selection of teachers, 5151, 5152.
- Demonstrators, &c. at Cambridge should be paid from University chest, 5167, 5171.
- There is an efficient staff of teachers in Cambridge University, 5189.

Astronomy.
- Stipend of Lowndean professor of astronomy at Cambridge should be increased, 5166.

Birmingham.
- Advantage of establishing a practical science school at Birmingham, 5109.

Botany.
- Botany was not included in Cambridge University curriculum until 1849, 5108.
- Botany an optional subject of examination for natural science scholarships at Cambridge, 5157.
- Good museum of botany at Cambridge University; it might be extended, 5108.

Cambridge University.
- Encouragement of physics and natural science at Cambridge; natural science not much studied, 5107–5109, 5131, 5134, 5175–5178.
- Museums at Cambridge, generally excellent; good mineralogical laboratory, and physical laboratory to be provided, 5108, 5167.
- Cambridge professorships; fellowships should not be permanently attached to professorships; professorships should have separate endowment from University, 5108, 5121–5126, 5172–5174.
- Demonstrators, &c., at Cambridge; appointment of demonstrators for anatomy and chemistry; University might furnish good teachers; there is an efficient staff of teachers at Cambridge, 5108, 5129, 5131, 5151, 5152, 5166, 5171, 5189.
- Examinations at Cambridge; institution of natural science examinations; they vary in different colleges, 5108, 5117, 5118, 5154, 5155, 5157, 5175–5178, 5182.
- Funds at Cambridge; 30,000*l.*, and 2,000*l.* a year, devoted to science; collegiate funds should be diverted to University, 5108, 5109, 5158–5170, 5188.
- Colleges at Cambridge; proposed 5 per cent. taxation agreed to by only four colleges; a fixed charge better than taxation by boards of representatives; statutes preferable to Act of Parliament with regard to collegiate taxation; colleges should voluntarily elect eminent professors; colleges would willingly give science rewards if there were good candidates, 5109, 5119–5126, 5137–5141, 5179, 5180.
- Cambridge professors; should hold more fellowships; should not be attached to a particular college; University should obtain the best men for professors; professors should have a share of students' fees, 5109, 5125, 5126, 5170, 5172–5174.
- Fellowships at Cambridge; objection to diminish the number; natural science fellowships would be given were candidates forthcoming; fellowships should not be permanently attached to professorships, 5109, 5123, 5124, 5134, 5137–5144, 5151, 5152, 5172–5174, 5179, 5180, 5182, 5185–5187.
- Mechanical engineering, mining, or shipbuilding could not be studied practically at Cambridge, 5109, 5190, 5191.
- Cambridge students; few select natural science; better in classics and mathematics than in science, 5117, 5118, 5123, 5134, 5137–5144, 5147, 5148, 5151, 5152, 5156, 5175–5180.

Cookson, Rev. H. W.—*Cambridge University* cont.
- Cambridge scholarships; want of proper candidates for natural science scholarships; examinations for scholarships vary in different colleges, 5123, 5137–5144, 5156, 5157, 5179, 5180.

Cambridge University Commission.
- Commission proposed that colleges should pay to University 5 per cent. on their incomes; the plan failed, 5109.

Chancellor of Cambridge University.
- Laboratory, apparatus, &c., for physical teaching, to be provided at Cambridge University, through the munificence of the Chancellor, 5108.

Chemistry.
- Chemistry was not included in Cambridge University curriculum until 1849, 5108.
- Stipend of professor of chemistry at Cambridge University just raised from 300*l.* to 500*l.* per annum, 5108.
- Appointment of a demonstrator of chemistry at Cambridge, 5108.
- Chemistry is one special subject in Cambridge natural science scholarship examinations, 5157.

Christ Church College (Cambridge).
- Christ Church College agreed to proposed 5 per cent. taxation for University purposes, 5109.

Degrees.
- Special natural science examinations for ordinary degree instituted at Cambridge University; few candidates, 5108, 5117, 5118.

Electricity. See *Physics.*

Engineering.
- Cambridge University not a good place for instruction in mechanical engineering, 5109.

Examinations.
- Institution of natural science examination for honours, and also for ordinary degrees, at Cambridge University, 5108, 5117, 5118.
- Natural science examinations not more difficult to conduct than examinations in classics and mathematics, 5111.
- In physics' examinations at Cambridge, mathematical theories are excluded, 5113–5116, 5154, 5155.
- Examinations for natural science scholarships vary in different colleges; chemistry is one subject in all, 5157.
- Cambridge students, at end of second term, pass an examination in elementary mathematics, Latin, Greek, &c.; they are then free to pursue science, 5175–5178.
- Large colleges at Cambridge have their own examinations; small colleges take the University examination, 5182.

Fees. See *Income and Expenditure.*

Fellowships.
- Objection to suppression of fellowships at Cambridge University; better to diminish average income; more fellowships might be held by professors, 5109.
- Colleges at Cambridge are willing to give fellowships for natural science; University gives every facility; but candidates for classics and mathematics are superior men, 5123, 5134, 5137–5144, 5179, 5180.
- Fellowships should not be permanently attached to professorships at Cambridge University, 5124.
- That Cambridge scientific fellowships may be obtained as easily as those for classics and mathematics is not generally known, 5147, 5148.
- Large number of fellowships at Cambridge desirable, with a view to selection of teachers, and attraction of young men of talent, 5151, 5152.
- Colleges at Cambridge, at their own discretion, should elect professors to fellowships, 5172–5174.
- Natural science fellowships to be given by some of the larger colleges at Cambridge; they have their own examination, 5182.
- Many fellowships at Cambridge are obtained by persons who take no part in the University business, 5185.
- Cambridge fellowships are the prizes which attract eminent men, 5186, 5187.

Funds. See *Income and Expenditure.*

Geology.
- Teaching of geology at Cambridge University; not included in University curriculum until 1849; high reputation of the geological museum, 5108.
- Geology an optional subject of examination for natural science scholarships at Cambridge, 5157.

Heat. See *Physics.*

Cookson, Rev. H. W.—cont.

Honours.
- Institution of examination for honours in natural science at Cambridge University, 5108.
- Honours' candidates at Cambridge pass an extra examination in algebra, trigonometry, and mechanics, 5175.

Income and Expenditure.
- 30,000*l.*, and 2,000*l.* a year, devoted to buildings, &c. for science purposes by Cambridge University, 5108.
- Income of professor of chemistry at Cambridge increased from 300*l.* to 500*l.* per annum, 5108.
- Collegiate funds should be made contributory to University instruction at Cambridge; a fixed charge (perhaps 5 per cent.) desirable; should be applied to stipends of professors, 5109.
- 4,000*l.* annually is paid out of University chest at Cambridge for professors; about 9,000*l.* per annum would result from proposed taxation of colleges; this should be devoted to professors, 5109, 5158–5170.
- Stipend of Lowndean professor of astronomy at Cambridge should be increased, 5166.
- Museums, assistants, &c., at Cambridge, should be paid out of the University chest, 5167.
- Cambridge professors should have a share of students' fees, 5170.
- Diminishing average income of all Cambridge fellowships preferable to decreasing their number, 5188.

Laboratories.
- Excellence of mineralogical laboratory at Cambridge University, 5108.
- Laboratory, &c. for physical teaching to be provided at Cambridge University, 5108.

Leeds.
- A practical science school should be instituted at Leeds, 5109.

Literature.
- Natural science examination not more difficult to conduct than literary one, 5111.
- Unfair to give scientific rewards at Cambridge University when better candidates in classics offer themselves, 5123, 5134, 5137–5144.
- That scientific fellowships are obtainable as easily as those for classics is not generally known, 5147, 5148.
- Examination in elementary Latin and Greek has to be passed by Cambridge students at end of second term, 5175–5178.

Lowndean Professor. See *Astronomy.*

Manchester.
- Desirability of having a practical science school at Manchester, 5109.

Mathematics.
- Mathematical tripos at Cambridge University; more weight to be given to physical subjects, 5108, 5112–5116.
- An examination in natural science not more difficult to conduct than one in mathematics, 5111.
- In physics' examinations at Cambridge, mathematical theories are excluded, 5113–5116, 5154, 5155.
- Not fair to give scientific rewards at Cambridge when there are better candidates in mathematics, 5123, 5134, 5137–5144.
- It is not generally known that scientific fellowships may be obtained as easily as mathematical at Cambridge, 5147, 5148.
- Examination in elementary mathematics, arithmetic, and Euclid, has to be passed by Cambridge students at end of second term; elementary algebra, trigonometry, and mechanics also, for honours' candidates, 5175–5178.

Mechanics.
- General principles of mechanics might be studied in universities, and their application learned in industrial centres, 5109.

Mineralogy.
- Mineralogy not included in Cambridge University curriculum until 1849, 5108.
- Excellence of mineralogical museum, working rooms, laboratory, &c., at Cambridge University, 5108.

Mining.
- Mining is a subject of which the principles only should be studied in universities, 5191.

Museums. See *Accommodation for Science Purposes.*

Natural Philosophy. See *Physics.*

Parliament.
- Statutes preferable to Act of Parliament, in regard to collegiate taxation at Cambridge, 5119.

Cookson, Rev. H. W.—cont.

Physics.
- Physics has been studied for a great number of years at Cambridge University, 5108.
- Changes in Cambridge mathematical tripos, giving more weight to physical subjects, 5108.
- Professorship of experimental physics just instituted at Cambridge; laboratories, &c. to be provided, 5108.
- Heat and electricity are included in natural sciences' tripos, and will be in mathematical tripos, at Cambridge, 5113–5116.
- In physics' examination at Cambridge mathematical theories are excluded, 5154, 5155.

Physiology.
- Physiology an optional subject of examination for natural science scholarships at Cambridge, 5157.

Practical Instruction.
- Desirability of establishing practical science schools in industrial centres; sound scientific instruction should be given, 5109, 5127–5129.
- Principles of mechanism might be studied at Cambridge, and application learned in industrial centres, 5109.

Professors.
- Collegiate funds at Cambridge should go towards stipends of University professors; but not scientific professors only, 5109, 5158–5170.
- More fellowships at Cambridge should be held by professors, 5109.
- Cambridge professors should not be attached to a particular college, 5109.
- Professors at Cambridge should be the best men the University could obtain, 5109.
- Colleges at Cambridge should have discretion of electing professors to fellowships, 5125, 5126, 5172–5174.
- Stipend of Lowndean professor of astronomy at Cambridge should be increased, 5166.
- Cambridge professors should have a share of students' fees, 5170.

Professorships.
- Professorship of zoology instituted, and professorship of anatomy made permanent, at Cambridge University, in 1866, 5108.
- Professorship of experimental physics just instituted at Cambridge, 5108.
- Cambridge fellowships should not be permanently attached to professorships, 5124.
- Professorships at Cambridge should have separate endowment from University, and colleges should, at discretion, elect particular professors into fellowships, 5125, 5126, 5172–5174.

Saint Peter's College (Cambridge).
- Saint Peter's College agreed to proposed 5 per cent. taxation for University purposes, 5109.

Salaries. See *Income and Expenditure.*

Shipbuilding.
- Of a subject like shipbuilding, the principles only should be studied in universities, 5191.

Scholarships.
- Natural science scholarships would be given willingly by colleges at Cambridge; every facility is afforded; but candidates in mathematics and classics come better prepared, 5123, 5137–5144, 5156, 5179, 5180.
- Cambridge natural science scholarship examinations vary in different colleges; chemistry is one subject in all, 5157.

Schools.
- Desirability of natural and physical science being taught in schools, 5109, 5131, 5134.
- Schools of practical science should be established in all great centres of mechanical industry; instruction should be both scientific and practical; universities might furnish teachers, 5109, 5127–5129.
- Several of the more important schools have made great advances in science teaching, 5132, 5133.
- Improved science teaching in public schools would have a favourable effect on universities, 5145, 5146.

Science.
- Encouragement of physics and natural science at Cambridge University, 5107, 5108.
- Examinations in natural science not more difficult to conduct than those in classics or mathematics, 5111.
- Increased natural and physical science teaching in universities and schools desirable, 5109.
- In great centres of industry schools of practical science should be instituted; the teaching should be scientific and practical; universities might furnish teachers, 5109, 5127–5129.

COOKSON, Rev. H. W.—*Science*—cont.
- Natural science not studied much at Cambridge, as affording no prospect of future career; more science teaching in schools would remedy this, 5131, 5134.
- Great advance in science teaching made by the more important schools, 5132, 5133.
- Cambridge students may pursue science after examination at end of second term, 5175–5178.

Students.
- Few students at Cambridge select natural science as a means of obtaining a pass degree; standard of science students is not improving, 5117, 5118, 5143, 5156.
- Students are not generally aware that they can obtain fellowships in science equally well with those in classics or mathematics, 5147, 5148.
- Better candidates for classical and mathematical than for scientific rewards at Cambridge, 5123, 5134, 5137–5144, 5179, 5180.
- Large number of fellowships at Cambridge an attraction to young men of talent, 5151, 5152.
- Cambridge students, after examination at end of second term, may pursue science, 5175–5178.

Trinity College (Cambridge).
- Trinity College, Cambridge, agreed to proposed 5 per cent. taxation for University purposes, 5109.
- Natural science fellowships to be given by Trinity College, 5182.

Trinity Hall (Cambridge).
- Trinity Hall, Cambridge, agreed to proposed 5 per cent. taxation for University purposes, 5109.

Universities.
- Both Universities should do a great deal more with respect to natural and physical science, 5109.
- Principles of mechanism might be studied at Cambridge, and application learned in industrial centres, 5109.
- Universities might furnish good teachers for science schools, 5129.
- Improved science teaching in public schools would have a favourable effect on universities, 5146.

See *Cambridge University.*

Zoology.
- Excellence of museum of zoology at Cambridge University, 5108.
- Professorship of zoology established at Cambridge in 1866, 5108.

LATHAM, REV. HENRY, M.A. (Index of his Evidence.)

Age of Students.
- Civil engineer students begin their apprenticeship at 17, and stay five years, 5209.
- Students in German polytechnic schools are from 19 to 23 years of age, 5217.
- Candidates for Indian civil service must be 17 to 21 years of age, 5232, 5234.

Apparatus for Science Purposes.
- Scientific apparatus should be cheaper; a Government repository might be instituted, 5211.
- Desirability of students being taught to handle apparatus, 5260.

Assistant Professors, Demonstrators, and Teachers.
- Demonstrator of chemistry appointed at Cambridge University; salary, 100*l.*, 5196.
- Diminution of private tutors at Cambridge, consequent on combination of colleges for lectures, 5198.
- Private tutors desirable at Cambridge, but they should not be considered as essential in ordinary cases, 5199, 5200.
- Technical schools would open a field for the employment of University men, &c., as teachers, 5210, 5248–5250, 5256.
- Teaching of college lecturers at Cambridge is most essential; preparation for examination rests with them, 5260–5266.
- A college tutor might instruct at once 20 or 30 students in classes for pass degree, and 10 or 12 for higher subjects, in mathematics, 15 in lower subjects, 8 or 10 in higher, 5277.

Astronomy.
- Promotion of study of physical astronomy at Cambridge University, 5271.

Botany.
- Botany is taught at Sidney Sussex College, Cambridge, 5193.
- Doubt of botany being a beneficial subject for schools, 5226.
- Botany carries many marks in Indian civil service examinations, 5237.

LATHAM, Rev. H.—cont.

Caius College (Cambridge).
- Combination of Caius with King's College and Trinity Hall, Cambridge, for lecture purposes, 5798.
- Caius College has lately devoted 800*l.* a year to science, 5271.

Cambridge Natural History Clubs. See *Natural History Clubs.*

Cambridge University.
- Colleges at Cambridge; combination for lectures on science; college combination might co-operate with and be subsidiary to University professoriate; college lecturers do the work of preparation for examinations; colleges would be glad to reward high-class men, 5193–5200, 5260–5263, 5267, 5271.
- Professors at Cambridge; professor of experimental physics appointed; professors should lecture, and have control of laboratories; a good professoriate, with museums, &c., desirable, 5193, 5260–5266, 5268.
- Assistant professors, &c., at Cambridge; demonstrator of chemistry appointed; diminution of private tutors; college lecturers most essential, 5196, 5198–5200, 5260–5266, 5277.
- Lectures at Cambridge; combination of colleges for lectures, 5193–5198, 5257–5259, 5261, 5266.
- Laboratories at Cambridge; physiological laboratory in new museum; University laboratories should be controlled by professors; college laboratories useful, 5193, 5268.
- Degrees at Cambridge; combined teaching of colleges for ordinary degrees, 5193–5198, 5205, 5206, 5225, 5277.
- Funds at Cambridge; professors of physics and chemistry are to have 500*l.* a year, and demonstrator of chemistry 100*l.*; University relieved by colleges to extent of 1,500*l.* year; 800*l.* a year devoted to science by Caius College, 5193, 5271.
- Cambridge students; approval of students choosing their own subjects, and giving their last year to them; few engineering students; colleges would be glad to reward high-class students, 5196, 5201–5208, 5225, 5230–5238, 5260, 5269–5271, 5277.
- Cambridge examinations; college tutors, not professors, do the work of preparation; approval of the special examinations, 5265, 5278, 5279.
- Boards of studies at Cambridge have had little practical effect, 5263, 5265.
- Scholarships at Cambridge; valuable scholarships given by many colleges, 5271.

See *Caius* and other Colleges.

Chemistry.
- Practical and theoretical chemistry is taught at St. John's College, Cambridge, 5193.
- Chemistry carries many marks in Indian civil service examinations, 5237.
- Chemical studies at Cambridge are under control of the professor, 5268.

Children.
- Imperfect training in mechanics of boys in public schools, 5225–5227.
- Doubtful if the mass of school-boys could be taught science properly, 5226.
- Boys who have an aptitude for science should be taught in special schools, 5228.
- In some schools boys have been taught mathematics well, 5228, 5229.
- Schools for modern languages and science would get many boys, but they would be of a different class from those at public schools, 5239, 5253–5256.

Cramming.
- Preparation for Indian civil service examination in an organized system of cram, 5235, 5236.

Degrees.
- Combined teaching of colleges at Cambridge, with a view to the ordinary degree, 5193–5198.
- In Cambridge natural sciences' tripos last year 18 took degrees; for the ordinary degree, 25 passed in natural and 13 in applied science, 5205.
- Fair amount of proficiency in science is required from those who take ordinary degrees at Cambridge, 5206.
- Nearly all which is done for the ordinary degree at Cambridge is learned in the University, 5225.
- For Cambridge pass degree, 20 or 30 students in classics might be taught at one time, 5277.

Electric Telegraphs.
- Government might aid technical schools in view of qualifying persons for electric telegraph department, 5211.

Latham, Rev. H.—cont.

Engineering.
- Few engineering students at Cambridge University; engineering profession is in favour of apprenticeship; students begin at 17, and stay five years, 5207–5209, 5241–5243.
- Practical work is considered of the greatest importance for engineering students; it is required in Whitworth examinations, 5244, 5247, 5252.

Examinations.
- Bad teaching of mechanics in public schools, as shown by the local examinations, 5225.
- Indian civil service examinations are physically and mentally injurious; too many subjects at once; candidates must be 17 to 21; cramming induced; science carries a large proportion of marks, 5230–5238.
- Practical as well as theoretical skill is required in Whitworth examinations, 5247, 5252.
- Lectures of Cambridge professors generally cannot be considered as preparation for examinations; college tutors do this work, 5265.
- Approval of present system of special examinations at Cambridge, 5278, 5279.

Fellowships.
- Science should not be forced into prominence by giving fellowships to inferior candidates, 5271.

Geology.
- Lectures on geology given at St. John's College, Cambridge, 5193.
- Geology carries many marks in Indian civil service examinations, 5237.

Germany.
- German polytechnic schools; advantage of analogous schools being established in England, 5210–5219, 5273–5275.
- German schools are Government institutions, but to a great extent are self-supporting, 5210, 5211.
- "Real Schulen" in Germany are for boys; they are considered inferior to the classical schools; they are preliminary to the polytechnic schools, 5217–5219.
- Bifurcation system in German schools is generally condemned, 5217.
- Contest between classics and science in Germany; classics having the best of it, 5217.
- Cheapness of scientific works and illustrations in Germany as compared to England; large number of scientific periodicals, 5215, 5220–5223.
- No domestic system attached to German schools; students live where they can, 5274.

Government.
- To establish technical schools, Government influence, or Government assistance meeting local effort, would be necessary, 5211.
- Continental technical schools are wholly Governmental, but partly self-supporting, 5211, 5275.
- Government might aid scientific investigations, publication of reports, &c., 5222.

Honours.
- In Cambridge natural sciences' tripos last year there were 18 in honours, 5205.

Income and Expenditure.
- Experimental physics' professor at Cambridge is to have 500*l.* a year; professor of chemistry raised to 500*l.*; demonstrator of chemistry to have 100*l.*, 5193.
- Colleges at Cambridge have relieved University to the extent of about 1,500*l.* a year, 5193.
- 800*l.* a year has lately been devoted to science by Caius College, Cambridge, 5271.

India.
- Examinations for civil service for India are injurious; too many subjects at same time; candidates are from 17 to 21; two or three Cambridge men compete annually; science carries a large proportion of marks; 5230–5238.

Indian Engineering College (Cooper's Hill).
- Cooper's Hill College will diminish the already small number of Cambridge engineering students, 5207.

King's College (Cambridge).
- Combination of King's College with Caius College and Trinity Hall, Cambridge, for lecture purposes, 5198.

Laboratories.
- Physiological laboratory open for practical instruction at the new museums, Cambridge, 5193.
- University laboratories at Cambridge should be under control of professors; small college laboratories useful, 5268.

Latham, Rev. H.—cont.

Lectures.
- Combination of colleges at Cambridge for lectures in natural science and higher physics and mathematics, 5193–5198, 5257–5259.
- System of college combination for lectures at Cambridge should co-operate with University professoriate, 5261.
- Professors' lectures at Cambridge generally are not a preparation for the examinations; college lecturers do this work, 5260–5266.
- A Cambridge professor should give at least one course of lectures, 5266.

Literature.
- Contest in Germany between classics and science; classics having the best of it, 5217.
- In classics, 20 or 30 students might be taught at one time for pass degree, and 10 or 12 for higher subjects, 5277.

Mathematics.
- Combination of college lecturers at Cambridge for teaching the higher mathematics, 5193–5196.
- Harder parts of mathematics could not be taught to a class of more than 6 to 10, 5196.
- Valuable mathematical knowledge, adapted to Cambridge University teaching, is given in some schools, 5228, 5229.
- In mathematics, a college tutor might instruct at once 15 students in low subjects and 8 or 10 in higher, 5277.

Mechanics.
- Bad teaching of mechanics in public schools, 5225–5229.

Natural History Clubs.
- Ray Club and Cambridge Field Naturalists' Club at Cambridge; comprise professors and undergraduates, 5201–5204.

Physics.
- Electricity and magnetism taught at Trinity College, Cambridge, 5193.
- Union of college lecturers at Cambridge for teaching the higher physics, 5193–5196.
- Harder parts of natural philosophy could not be taught to a class of more than 6 to 10 students, 5196.
- Electricity and magnetism carry many marks in Indian civil service examinations, 5237.
- Practical instruction given to students of physics at Cambridge, 5260.
- Promotion of study of physical optics at Cambridge, 5271.

Physiology.
- Teaching of physiology at Cambridge by new prælector of Trinity; laboratory instruction given, 5193.

Polytechnic Schools. See *Schools.*

Practical Instruction.
- Practical instruction in physiology given in laboratory in new museums at Cambridge University, 5193.
- Proposition to establish a school of practical science near Cambridge; idea abandoned, 5207.
- Advantage of practical and theoretical science schools being side by side, 5207.
- Industrial centres would be well adapted for theoretical and practical instruction, 5245.
- For engineering students practical instruction is considered of the highest importance; it is required in Whitworth examinations, 5244, 5247, 5252.
- Desirability of students being taught use of apparatus practically, 5260.
- Practical instruction given to Cambridge students of physics, 5260.
- In German polytechnic schools practical instruction is given, 5273.

Professors.
- Professor of experimental physics appointed at Cambridge University; salary 500*l.*, 5193.
- Stipend of professors of chemistry at Cambridge raised from 300*l.* to 500*l.* a year, 5193.
- Both University professors and college lecturers are requisite at Cambridge, 5260–5266.
- Lectures of Cambridge professors generally are not a preparation for the examination, 5265.
- A Cambridge professor should give at least one course of lectures, 5266.
- Chemical studies at Cambridge are under control of professor of chemistry, 5268.
- Laboratories, &c., at Cambridge should be under control of professors, 5268.

LATHAM, Rev. H.—cont.

- *Professorships.*
  - Establishment of professorship of physics at Cambridge University, 5193.
- *Ray Club.* See *Natural History Clubs.*
- *Rigg, Mr.*
  - Mr. Rigg's technical school at Chester did good service, 5213.
- *Saint John's College (Cambridge).*
  - Combination of St. John's with Sidney and Trinity Colleges, Cambridge, for lecture purposes, 5193–5197, 5257, 5258.
  - Theoretical and practical chemistry and geology are taught at St. John's College, 5193.
- *Scholarships.*
  - Natural science scholarships of large value at many of the colleges at Cambridge, 5271.
- *Schools.*
  - Projected practical science school near Cambridge; abandoned; engineers were opposed to it, 5207, 5241–5243.
  - Advantage of practical and theoretical science schools being side by side, 5207.
  - Technical schools would employ scientific men; Government aid would be essential; education should be adapted to locality; halls in connexion might be opened privately, 5210, 5211, 5248–5250, 5272–5276.
  - Polytechnic and "Real Schulen" in Germany; bifurcation school system condemned, 5210–5219.
  - Continental technical schools are wholly Governmental, but are partly self-supporting, 5211.
  - Science teaching in schools has been little affected by new regulations respecting science at Cambridge, 5225.
  - Mechanics is badly taught in schools, 5225–5229.
  - Natural history teaching in schools desirable only so far as it encourages taste, 5226.
  - Doubt of science being a good subject for school teaching, 5226.
  - Natural science should be taught in special schools, and to boys having an aptitude for science, 5228.
  - Mathematics is well taught at some public schools, 5228, 5229.
  - Schools teaching modern languages and science would get many boys, but not of the public school class; Cambridge men might become teachers, 5239, 5253–5256.
- *Science.*
  - Promotion of science at Cambridge University; combination of lecturers for teaching higher mathematics, &c., 5192–5199.
  - Practical science school proposed to be instituted near Cambridge; scheme abandoned, 5207.
  - Advantage of having practical and theoretical science schools side by side, 5207.
  - Drawback to science at Cambridge in there being so few courses in life where scientific knowledge is remunerative, 5209.
  - Large number of scientific works brought out in Germany; produced much cheaper than in England, 5215, 5220–5223.
  - Contest in Germany between classics and science; classics having the best of it, 5217.
  - The new regulations as to science at Cambridge have had but little effect on scientific teaching in schools, 5225.
  - Mechanics is badly taught in schools; natural history teaching in schools beneficial only as encouraging a taste; mathematics is well taught in some schools, 5225–5229.
  - Doubt of science being a good subject for school-teaching, 5226.
  - Science would be better taught in special than in general schools; the boys would be of a different class, 5253–5256.
- *Science Schools.* See *Schools.*
- *Scientific Works.*
  - German scientific books; their great number, and cheapness of production, as compared with English, 5215, 5220–5223.
  - Government might aid scientific investigations, and publication of scientific reports, 5222.
- *Sidney Sussex College (Cambridge).*
  - Combination of Trinity and St. John's with Sidney College, Cambridge, for lecture purposes, 5193–5197, 5257, 5258.
  - Botany is taught at Sidney College, 5193.
- *Students.*
  - Harder parts of mathematics and natural philosophy could not be taught to more than 6 to 10 students at once, 5196.

LATHAM, Rev. H.—*Students*—cont.

  - Natural history clubs at Cambridge supported by undergraduates, who make botanical and geological excursions, 5201–5204.
  - In the Cambridge natural sciences' tripos last year there were one ninth of the graduates of the year, 5205.
  - Approval of allowing Cambridge students to choose their own subject, and give their last year to it, 5206.
  - Few engineering students at Cambridge University; engineers prefer apprenticeship system, 5207, 5208.
  - Students in German polytechnic schools attend what courses they please; they are from 19 to 23 years of age, 5215, 5217.
  - Cambridge students not found to be better for the mechanics they had learned at school, 5225.
  - Exhaustive effect on candidates of Indian civil service examination; too many subjects, 5230–5238.
  - Many Cambridge men formerly competed for Indian civil service; now, two or three annually, 5233.
  - For engineering students, practical work is considered of the highest importance; essential for Whitworth candidates, 5244, 5247, 5252.
  - Advantage of practical instruction to students generally, 5260.
  - Colleges at Cambridge would be glad to offer rewards to students of high class, 5269–5271.
  - A college tutor might instruct at once 20 or 30 students in classics for pass degree, and 10 or 12 for higher subjects; in mathematics, 15 in low subjects, and 8 or 10 in higher, 5277.
- *Teachers.* See *Assistant Professors, &c.*
- *Technical Schools.* See *Schools.*
- *Trinity College (Cambridge).*
  - Combination of Trinity with St. John's and Sidney Colleges, Cambridge, for lecture purposes, 5193–5197, 5257, 5258.
  - Teaching of physiology at Cambridge by new prælector of Trinity College; laboratory instruction given, 5193.
  - Electricity and magnetism taught at Trinity College, 5193.
- *Trinity Hall (Cambridge).*
  - Combination of Trinity Hall with King's and Caius Colleges, Cambridge, for lecture purposes, 5198.
- *Whitworth, Sir Joseph.* See *Examinations.*
- *Zoology.*
  - Doubt of zoology being a beneficial subject for schools, 5226.
  - Zoology carries many marks in Indian civil service examinations, 5237.

ATKINSON, THE REVEREND EDWARD, D.D. (Index of his Evidence.)

- *Cambridge University.*
  - Funds at Cambridge University; derived from landed property, fees, &c., 5282, 5283, 5308.
  - Colleges at Cambridge; should contribute to University expenses; many are desirous of doing so; various methods of taxation proposed, viz., per-centage on revenues and on non-resident fellowships, election of professors to college fellowships, &c.; an enabling Act of Parliament desirable; inter-collegiate lecture system, 5284–5295, 5302, 5303, 5305, 5306, 5308.
  - Fellowships and scholarships at Cambridge; proposal to tax non-resident fellowships; proposed election of professors to fellowships; objection of colleges to give up scholarships, 5286, 5293, 5295, 5296.
  - Degrees at Cambridge; inter-collegiate lecture system is adapted to honours' and to ordinary degree candidates, 5304–5306.
    - See *Clare College (Cambridge).*
- *Clare College (Cambridge).*
  - No direct provision for science teaching at Clare College; scholarship given annually, but no fellowship; every disposition to encourage science, 5297–5301.
  - Inter-collegiate lectures in association with Clare College, 5295, 5302, 5303.
  - Clare College science students, attending other colleges, have a portion of their fees remitted, 5295.
- *Degrees.*
  - Inter-collegiate lecture system at Cambridge University is adapted both to honours' men and ordinary degree candidates, 5304.
  - The numerous branches of knowledge in which an ordinary degree at Cambridge can be obtained have necessitated new arrangements for lectures, 5305, 5306.
- *Fees.* See *Income.*

Atkinson, The Rev. E.—cont.

Fellowships and Scholarships.

To raise University funds at Cambridge, one proposition is, to levy 10 per cent. upon the non-resident fellowships, 5286.

Proposed election of professors to fellowships at Cambridge, 5286.

Colleges at Cambridge cannot diminish fellowships and scholarships at their own discretion, 5293.

Objection of colleges at Cambridge to give up scholarships; great efforts of late to increase their number, 5293.

Physical science scholarship given annually by Clare College; no good candidate the first year, and a very good one the second, 5295, 5296.

Income and Expenditure.

Cambridge University income is about 1,500*l.* a year from landed and funded property, about 20,000*l.* from fees, and about 13,000*l.* from special endowments, 5282.

More than a safe proportion of the income of Cambridge University has been appropriated, 5283.

Additional funds for Cambridge University must come from the colleges; many colleges would contribute, but have not the power, 5284–5294, 5308.

Lectures.

Inter-collegiate lectures in association with Clare College, Cambridge, 5295.

Approval of system of inter-collegiate lectures at Cambridge, as becoming essential, 5302, 5303.

New lecture arrangements at Cambridge necessitated by the numerous branches of knowledge in which an ordinary degree can be obtained, 5305, 5306.

Parliament.

An enabling Act of Parliament desirable in view of college taxation at Cambridge, 5287–5291.

Professors.

Proposed election of professors to fellowships at Cambridge, 5286.

Scholarships. See under *Fellowships and Scholarships.*

Students.

Students of Clare College, Cambridge, attending science lectures in other colleges, have a portion of their fees remitted, 5295.

For Clare Hall science scholarship no good student competed the first year, but a very good one the second year, 5296.

BONNEY, Reverend THOMAS GEORGE, B.D.
(Index of his Evidence.)

Accommodation for Science Purposes.

Cambridge museums and laboratories want increasing very much, 5354, 5363.
See *Laboratories.*

Anatomy.

Anatomy is one subject of examination for the natural science exhibition at St. John's College, Cambridge, 5314.

Cambridge professorship of zoology and comparative anatomy should be divided, 5354.

Assistant Professors, Demonstrators, and Teachers.

College lecturers at Cambridge should act in concert with professors; they might be allowed occasional use of University laboratories, &c., 5336–5344, 5386, 5408–5411.

Appointment of Cambridge tutors and lecturers varies in different colleges, 5353.

More assistants or demonstrators wanted at Cambridge University; election of professors to fellowships would set free funds for this purpose, 5354, 5363.

Professors should give broad views, and college lecturers should fill up details, 5406.

A greater number of lecturers, and division of fellowships, would tend to minimize private tutors at Cambridge, 5443–5447.

Botany.

Lectures on botany at Sidney Sussex College, Cambridge, 5310.

Botany is one optional subject of examination for the natural science exhibition at St. John's College, Cambridge, 5314.

Cambridge University.

Lectures at Cambridge; inter-collegiate lectures; should be subject to a regulating board of studies, 5310, 5316, 5317, 5331–5335, 5340, 5431, 5441, 5442.

Cambridge scholarships; natural science scholarships offered by many colleges; every college should hold out similar inducements, 5311–5314, 5378, 5380, 5383, 5399, 5400, 5402, 5440, 5458.

Bonney, Rev. T. G.—*Cambridge University*—cont.

Cambridge students; good prizes will bring good students; equality of candidates in different triposes, 5311–5313, 5317, 5375–5383, 5400, 5404, 5440, 5452, 5457, 5458.

Cambridge examinations; natural science tripos requires little mathematics; examinations are in part practical; *vivâ voce* examinations proposed; separate examinations in separate colleges objectionable, 5312–5315, 5376, 5383, 5448–5450, 5452, 5456, 5457.

Great want of elasticity in University system at Cambridge; cumbrous mode of effecting any change, 5318.

Governing body wanted at Cambridge University; existing electoral roll a better body than the senate; board representing professors and college teachers wanted; and also a board of finance, representing colleges and University, 5318–5329, 5336–5344, 5358, 5384–5392, 5419–5424, 5433–5438, 5441, 5442, 5459–5461.

Cambridge professors; change in mode of election desirable; should act in concert with college lecturers; they are insufficiently paid, 5325–5344, 5354, 5384–5386, 5406.

Degrees at Cambridge; objection to a minimum of natural science being required for a degree, 5429, 5430.

Colleges at Cambridge; too great separation between colleges and University; board representing professors and college teachers desirable; colleges should be governed by working fellows; colleges must augment University finance; consolidation of fellowships preferable to college taxation; all colleges should offer rewards for science; difficulty arising from colleges beginning and ending work at different times; college lecturers should be subject to professors; objection to separate examinations in separate colleges, 5336–5368, 5374–5447, 5456.

Demonstrators, &c., at Cambridge; college lecturers should act in concert with professors; more assistants and demonstrators wanted; more lecturers would minimize private tutors, 5336–5344, 5353, 5354, 5363, 5386, 5406, 5408–5411, 5443–5447.

Cambridge fellowships; prize and working fellowships desirable; consolidation of fellowships preferable to collegiate taxation; except in case of working fellowships, celibacy should not be a condition, 5345, 5350, 5358–5368, 5378, 5381, 5382, 5393–5398, 5419, 5431, 5433, 5439, 5443–5447.

Funds at Cambridge; finance pinched in every department of science; University could make good use of an additional 10,000*l.* a year; separate board of finance wanted, 5348, 5349, 5354–5370, 5373, 5386, 5412–5418, 5423, 5459–5461.

Museums and laboratories at Cambridge want increasing, 5354, 5363.

Cambridge professorships; more wanted; consolidation of fellowships into professorships desirable, 5354, 5360–5362, 5368–5371, 5419, 5433.
See under *Saint John's* and other Colleges.

Chemistry.

Lectures on chemistry, with practical instruction, at St. John's College, Cambridge, 5310.

Chemistry is one subject of examination for natural science exhibition at St. John's College, Cambridge, 5314.

Chemical professor at Cambridge University lectures about 140 times a year, 5335.

St. John's College, Cambridge, has a small chemical laboratory, 5387.

Experimental physics has been treated as chemical physics at Cambridge; this will probably be altered, 5405.

Clergymen.

Education questions at Cambridge University are too much decided by the clerical section, 5318, 5321.

Degree.

Objection to requiring a minimum of natural science as a necessary qualification for a Cambridge degree, 5429, 5430.

Education.

Questions of education at Cambridge should be settled by those engaged in the work, 5318.

Election of Professors. See *Professors.*

Examinations.

Annual natural science examination at St. John's College, Cambridge; special examination for exhibitions, 5312–5315.

Natural sciences tripos examination at Cambridge is in chemistry, botany, geology, mineralogy, zoology, comparative anatomy, and comparative physiology; but little mathematics required, 5376.

BONNEY, Rev. T. G.—*Examinations*—cont.

Candidates for Cambridge natural science scholarships are examined solely in the sciences; they have to pass the "previous examination" in two years, 5383, 5457.

Science examinations at Cambridge are partly practical; *vivâ voce* examinations are proposed, 5448–5450.

Approval, on the whole, of high-class competitive examinations, 5452.

Waste of power at Cambridge in holding separate examinations in separate colleges, 5456.

Exhibitions. See *Scholarships and Exhibitions.*

Fellowships.

Two classes of fellowships desirable at Cambridge:— 1. Prize fellowships, of limited tenure and small value; 2. Working fellowships, involving residence, college work, college government, and a few lectures, 5345, 5350, 5393–5398, 5425–5428, 5431–5433.

A man manifesting a tendency to specialize himself might be put into a working fellowship at Cambridge, 5346, 5347.

Better to consolidate Cambridge fellowships into professorships than tax colleges; two fellowships about equal to one professorship; no power in University to effect this, 5358–5368, 5419.

Celibacy should not be a condition if Cambridge fellowships should be consolidated; celibacy should be retained in case of working fellowships, 5360, 5396–5398.

Certain colleges at Cambridge have elected professors to fellowships, 5361, 5362.

Cambridge fellowships appropriated to science must be thrown open to the whole University, 5378, 5439.

Some colleges at Cambridge prefer giving fellowships solely for classics and mathematics, 5381, 5382.

Division of fellowships at Cambridge into prize and tutorial fellowships would tend to minimize the private tutors, 5443–5447.

Geology.

Geological lectures at St. John's College, Cambridge; principally attended by those who study science specially, 5310, 5317.

Geology is one optional subject of examination for the natural science exhibition at St. John's College, Cambridge, 5314.

Income and Expenditure.

St. John's College natural science lectureships are paid out of general college fund, not out of fees; 600*l.* paid annually, 5348, 5349.

Cambridge University finance is pinched in every department of science; it must be augmented from colleges, 5354–5357.

Consolidation of fellowships into professorships preferable to a per-centage taxation of colleges at Cambridge, 5358–5368.

Distrust of Cambridge University management as respects finance, 5358, 5459.

700*l.* a proper endowment for a professorship, 5369, 5370.

Cambridge University could make good use of an additional 10,000*l.* a year; more would be wanted ultimately, 5373, 5412–5418.

All the funds at Cambridge University should be controlled by the electoral roll, or by a representative financial board, 5459–5461.

Laboratories.

Laboratory instruction at Cambridge; St. John's College has a small chemical laboratory, 5310, 5387.

College lecturers at Cambridge should be allowed occasional use of University laboratories, 5384, 5408–5411.

Small inexpensive laboratories desirable in colleges at Cambridge, 5388.

Lectures.

Lectures in natural science at St. John's College, Cambridge, 5310.

Inter-collegiate lectures at Cambridge; system likely to be successful, 5310, 5316, 5317, 5340.

Professors' lectures at Cambridge vary in number; most professors should lecture 16 times in each of two terms; chemical professor gives about 140 lectures a year, 5331–5335.

Working fellows should not lecture to same extent as college lecturers, 5431.

Lectures at Cambridge, both professorial and collegiate, should be subject to a regulating board of studies, 5441, 5442.

Literature.

Some colleges at Cambridge prefer giving fellowships solely for classics and mathematics, 5382.

Classical, mathematical, and scientific high-class men at Cambridge are of about equal ability, 5404.

BONNEY, Rev. T. G.—cont.

Marriage of Fellows.

Cambridge fellows holding professorships need not vacate on marriage; celibacy restriction should be retained in the case of working fellowships, 5360, 5395–5398.

Mathematics.

Little mathematics required in Cambridge natural sciences' tripos examinations, 5376.

Mathematical and classical fellowships preferably given by some colleges at Cambridge, 5382.

In natural science, mathematical, and classical triposes at Cambridge, the high-class candidates are of about equal ability, 5404.

Original Research.

College lecturers at Cambridge might, by arrangement, leave professors free for original research, 5338.

Working fellows at Cambridge might lecture on the subject of their research, 5431.

Original research would be gladly rewarded by colleges at Cambridge, 5453.

Cambridge system tends to encourage original research, 5454, 5455.

Quantity of work thrown on residents at Cambridge tends to retard original research, 5455, 5456.

Physics.

Lectures on electricity and magnetism given at Trinity College, Cambridge, 5310.

Electricity, heat, and light are subjects of examination for natural science exhibitions at St. John's College, Cambridge, 5314.

New professorship of physics at Cambridge University will probably have to be subdivided, 5354.

Complaint of experimental physics not being considered a separate subject in Cambridge natural sciences tripos, 5405.

Physiology.

Lectures and practical instruction in physiology given at the new museums at Cambridge, 5310.

Physiology and anatomy are subjects of examination for natural science exhibition at St. John's College, Cambridge, 5314.

A professor of physiology is wanted at Cambridge University, 5354.

Practical Instruction.

Practical instruction in chemistry and physiology at Cambridge, 5310.

Professors.

Election of Cambridge professors; change desirable; small boards of persons experienced in the science desirable; foreign element not objectionable, 5325–5329.

Cambridge professors should reside two thirds of two of the terms, 5330.

Professors' lectures at Cambridge vary in number; chemical professor lectures about 140 times a year, 5331–5335.

Professors at Cambridge should act in concert with, and have control of college lecturers; the co-relation should be official; board of education representing both desirable, 5336–5341, 5384–5386.

Cambridge professors are insufficiently paid; more professors are wanted, 5354.

At Cambridge, professors should teach broad and general views; college lecturers should fill up details, 5406.

Professorships.

More professorships will be wanted at Cambridge University; professorship of physiology required; professorship of zoology and comparative anatomy, and new professorship of physics, will have to be subdivided, 5354.

Consolidation of Cambridge fellowships into professorships preferable to collegiate taxation; two fellowships would provide one professorship; no power in University to effect this, 5358–5368, 5419.

Celibacy should not be a condition if Cambridge fellowships were consolidated into professorships, 5360.

Certain colleges at Cambridge have consolidated professorships into fellowships, 5361, 5362.

About 700*l.* would be a proper endowment for a professorship; few at Cambridge reach that, 5369, 5370.

Professorships in French, German, Anglo-Saxon, &c. are wanted at Cambridge, 5371.

Holders of professorships attached to particular colleges would become ex-officio fellows of those colleges, 5433.

Saint John's College (*Cambridge*).

Promotion of science at St. John's College, Cambridge; lectures on chemistry and geology; laboratory; inter-collegiate lectures, 5309–5317.

Exhibitions and scholarships for natural science offered by St. John's College, 5311–5313.

Bonney, Rev. T. G.—*St. John's College* (*Cambridge*)—cont.
Annual examination in natural science at St. John's College; special examination for exhibitions, 5312–5315.
Lectureships in natural science at St. John's College are paid, not out of fees, but out of general fund, 5348.
No professor has been elected to a fellowship by St. John's College; no fellowship has been offered, 5361, 5378.
St. John's College, Cambridge, has a small chemical laboratory, 5387.
Natural science exhibition given annually by St. John's College; open to boys in schools, 5402.
No difficulty in finding candidates for the St. John's College exhibitions, 5458.

Scholarships and Exhibitions.
Natural science exhibitions at St. John's College, Cambridge; no difficulty in finding candidates, 5311–5314, 5378, 5458.
Many colleges at Cambridge have offered natural science scholarships, 5380.
Natural science scholarship candidates at Cambridge are examined solely in the sciences; they have to pass the "previous examination" in two years, 5383, 5457.
Foundation scholarships at Cambridge are not advertised beforehand, 5399, 5400.
Annual natural science exhibition at St. John's College, Cambridge; open to boys in schools, 5402.
Regarding scholarships, every college at Cambridge should hold out inducements to students, 5440.

Schools.
An annual natural science exhibition, for which boys in schools can compete, is given by St. John's College, Cambridge, 5402.

Science.
Promotion of science at St. John's College, Cambridge, 5309–5317.
See *Cambridge University*.

Sidney Sussex College (*Cambridge*).
Combination for lectures of Sidney Sussex with Trinity and St. John's Colleges, Cambridge, 5310.

Students.
About 10 candidates compete for each natural science exhibition at St. John's College, Cambridge, 5311–5313.
Geological lectures at St. John's College are chiefly attended by students who take up the science specially, 5317.
Good prizes should be offered to induce good students to enter Cambridge; eminent men would gain rewards, 5375–5383.
Inducements for students to enter Cambridge should be offered by every college, 5378, 5440.
Candidates for natural science scholarships at Cambridge are examined solely in the sciences; they have to pass the "previous examination" in two years, 5383, 5457.
A "scholar" at Cambridge is actually a member of a foundation, 5400.
Equality of high-class candidates in the mathematical, classical, and natural science triposes at Cambridge, 5404.
Competitive examinations injure some students and improve others, 5452.
Natural science exhibition candidates at Cambridge are not required to pass a previous examination, 5457.
No difficulty in finding candidates for the St. John's College exhibitions, 5458.

Trinity College (*Cambridge*).
Combination for lectures of Trinity with Sidney Sussex and St. John's Colleges, Cambridge, 5310.

Zoology.
Professorship of zoology and comparative anatomy at Cambridge University should be divided, 5354.

CARTMELL, Reverend JAMES, D.D. (Index of his Evidence.)

Accommodation for Science Purposes.
Museums, laboratories, &c., wanted at Cambridge University, 5472.

Apparatus for Science Purposes.
Apparatus, and places to put it in and to use it, are wanted at Cambridge University, 5472.

Assistant Professors, Demonstrators, and Teachers.
Additional assistants are wanted by Cambridge University professors, 5471.

Cartmell, Rev. J.—cont.
Cambridge University.
Funds at Cambridge wanted for professors' stipends, museums, &c.; funds must come from colleges; objection to general taxation of colleges; 5,000*l.* or 6,000*l.* a year additional sufficient at present, 10,000*l.* excessive; when raised, funds should be chiefly devoted to science, 5466–5493, 5504, 5510–5518, 5521–5526, 5538–5544.
Cambridge professors; they should have about 700*l.* a year; a few in natural science wanted; they require assistants; they should be independent of colleges, 5466–5471, 5492, 5529, 5530.
Museums, apparatus, &c., wanted at Cambridge University, 5471, 5472.
Colleges at Cambridge; they must provide funds for University; objection to a general tax upon the whole distributable income; members of colleges should not discuss questions affecting their personal interest; funds raised from colleges should be trust funds, and should mainly go to increase professors' stipends; independence of colleges as to lectures, &c. should not be interfered with, nor vested interests, 5474, 5478–5544.
Cambridge fellowships; non-resident fellowships might be taxed, and paid less; professorships should not be compulsorily attached to fellowships; objection to limiting tenure of fellowships, 5478–5492, 5504–5509, 5533–5536.
Cambridge professorships should not be compulsorily attached to fellowships; natural science professorships have now the greatest claim at Cambridge, 5492, 5511–5513.
Scholarships at Cambridge; natural science scholarships have had good candidates, 5494–5503.
Cambridge students; good men have competed for natural science scholarships; undergraduates are to be offered increased scholarships, 5494–5509.
Examinations at Cambridge; "previous examination" must be passed by candidates for natural science scholarships; University examinations are generally taken for fellowships, 5497–5500, 5507–5509.
Cambridge University government; studies, &c. should be left to control of senate; no alteration needed at present; collegiate taxation should be determined by external authority; electoral roll should not have authority over studies, 5527–5532, 5537.

Chemistry.
An assistant recently provided for chemical professor at Cambridge; more such assistance needed, 5471.

Christ Church College (*Cambridge*).
Scholarships for science offered by Christ's College, Cambridge; candidates good; scholarships for undergraduates to be increased, 5494–5503.
Christ's College is at liberty to appropriate its funds to encourage natural science, 5504.
Christ's College would give a fellowship to any member distinguished in natural science, 5504–5509.

Examinations.
Candidates for natural science scholarships at Christ's College, Cambridge, must pass the "previous examination," 5497–5500.
Few of the smaller colleges at Cambridge have examinations for fellowships; University examinations are taken, 5507–5509.

Fellowships.
Non-resident fellowships at Cambridge have advantages; they might be taxed for University purposes; about 15 per cent. might be deducted, 5478–5491, 5533–5536.
A less sum than is now given to non-resident fellows at Cambridge would be sufficient, 5480.
Resident Cambridge fellows should simply be required to reside a portion of the year, 5484.
Objection to compulsory attachment of professorships to fellowships at Cambridge, 5492.
Christ's College, Cambridge, would give a fellowship to any member distinguished in natural science, 5504–5509.
No examination for fellowships at Christ's College; a high place in natural sciences' tripos is sufficient, 5507–5509.
Objection to limiting tenure of non-resident Cambridge fellowships, 5533–5536.

Income and Expenditure.
Cambridge professors should have from 500*l.* to 800*l.* a year, or perhaps 700*l.*; few scientific professors' incomes exceed 500*l.*, 5466–5470, 5516–5518.
Funds for apparatus, museums, and laboratories are wanted at Cambridge, 5472.

CARTMELL, Rev. J.—*Income and Expenditure*—cont.
- Large addition to Cambridge University income required; it must come from the colleges; it should go to increase stipends of professors, 5473–5477, 5516–5520.
- Cambridge University income from endowment is rather less than 2,000*l.* a year; remainder comes from special endowments, fees, and capitation tax; all is disposed of, 5475–5478.
- Objection to a general tax upon distributable income of colleges at Cambridge, 5478–5491.
- Income of non-resident fellows at Cambridge might be taxed; 15 per cent. (about 5,000*l.* a year) might be deducted, 5478–5491, 5533–5536.
- Less than is now given would be sufficient for Cambridge non-resident fellows, 5480.
- An additional 5,000*l.* or 6,000*l.* a year would supply the requirements of Cambridge University for a long time; 10,000*l.* would be excessive, 5486, 5487, 5521–5526, 5543.
- A commission (empowered by the Legislature) might organize a scheme of finance for Cambridge University, 5490, 5510–5515, 5538–5541.
- Distrust of University finance management at Cambridge has no foundation; the funds are administered thriftily, 5493.
- No disability at Christ's College, Cambridge, as to appropriation of funds to natural science, 5504.
- All funds raised from colleges at Cambridge should be trust funds, 5510.
- Funds raised at Cambridge should be first chiefly devoted to natural science, 5510–5515.
- A large accession of members at Cambridge would increase the University income, by fees, &c., 5525, 5526.

Laboratories. See *Accommodation for Science Purposes.*

Lectures.
- Lectures at Cambridge are controlled by boards of studies, of which professors are members; alteration not needed, 5529, 5530.

Parliament.
- A commission (under legislative authority) might organize a finance scheme for Cambridge University; Act of Parliament not desirable for details, 5488–5490, 5510–5515.

Professors.
- Incomes of Cambridge University professors are inadequate; between 500*l.* and 800*l.* a year desirable, or perhaps 700*l.*, 5466–5470, 5516–5518.
- A few additional professors in natural science are wanted at Cambridge, 5466–5470.
- Cambridge professors require additional assistants, 5471.
- Professors at Cambridge should be independent of colleges; colleges should elect professors to fellowships at will, 5492.
- Cambridge professors belong to boards of studies, to which their lectures must be adapted; other directing authority is not needed, 5529, 5530.

Professorships.
- Cambridge professorships should not be compulsorily attached to fellowships, 5492.
- Natural science professorships have the greatest claim at present in Cambridge University, 5511–5513.

Salaries. See *Income and Expenditure.*

Scholarships.
- Natural science scholarships at Christ's College, Cambridge; candidates good; they will have to pass the "previous examination," 5491–5502.
- Proposed increase of scholarships for undergraduates studying natural science at Christ's College, 5503.

Science.
- Promotion of science at Cambridge University; extension desirable, 5465–5511.

Students.
- Good competitors for natural science scholarships at Christ's College, Cambridge; they have to pass the "previous examination," 5491–5502.
- Proposed increase of scholarships for undergraduates studying natural science at Christ's College, 5503.
- Christ's College, Cambridge, would give a fellowship to any of its students distinguished in natural science, 5504–5509.

Whateley, Archbishop.
- Objection of Archbishop Whateley to limiting tenure of fellowships, 5535.

CLARK, REVEREND WILLIAM GEORGE, M.A. (Index of his Evidence.)

Accommodation for Science Purposes.
- Museums at Cambridge are very defective; much more extensive buildings wanted, 5551.
- Museum building fund and general building fund at Cambridge have each 1,000*l.* a year; museums' maintenance fund is allowed 1,500*l.* a year, which is inadequate, 5584.

Assistant Professors, Demonstrators, and Teachers.
- Additional demonstrators are wanted at Cambridge University, 5551.
- Trinity College fellows, being lecturers, tutors, &c., hold their fellowships during office, and, after 10 years of office, for life, if they do not marry, 5567.
- There are 16 or 17 tutors and lecturers at Trinity College, 5588.

Cambridge University.
- Museums at Cambridge University are very defective, 5551, 5584.
- Funds at Cambridge; funds should be raised by college taxation; incomes of colleges will increase; masters of arts' payments form a great part of University revenue, 5551–5554, 5557–5563, 5583–5586.
- Cambridge professors; additional professors wanted; professors should have larger salaries; masters of colleges should be chosen from professors, 5551, 5554, 5555, 5585, 5586.
- Cambridge lecturers, &c.; demonstrators wanted; 16 or 17 tutors and lecturers at Trinity College, 5551, 5567, 5588.
- Colleges at Cambridge; per-centage taxation desirable; masterships of colleges might be made more available to educational purposes, and might be combined with professorships; prospective increase of college revenues, 5554–5568, 5587, 5588.
- Cambridge professorships; fellowships might be consolidated into professorships, 5556, 5564.
- Cambridge fellowships; some might be abolished or suspended, or consolidated into professorships; objection to taxing non-resident fellowships; non-resident fellowships should be terminable in seven years, 5559, 5568.
- Cambridge students; natural science students exempt from Greek; honours' students of natural sciences' tripos would come into government of University, 5569, 5570, 5577–5582.
- Cambridge examinations; natural science degree candidates (not ordinary degree candidates) are to be exempted from examination in Greek; candidates for the four triposes are exempt from the general examination, 5569–5574, 5577, 5578.
- Government of Cambridge University; senate a scattered and heterogeneous body; for educational purposes, a much smaller body, composed of residents, would be desirable; senate must not be trenched upon, 5576, 5582, 5583.
- Degrees at Cambridge; science degrees will be attainable without Greek; change of title of degrees not desirable, 5565, 5569, 5570, 5577, 5578, 5589, 5590.

Cambridge University Commission.
- The five per cent. taxation of colleges proposed by Cambridge University Commission was not carried out; opinion is more favourable now, 5552, 5553.

Clergymen.
- Cambridge non-resident fellowships do not terminate at all if holder takes holy orders, except in case of marriage, or taking one of the large college livings, 5566.

Degrees.
- Seven years after taking M.A. degree would be a good time to terminate non-resident fellowships at Cambridge, 5565.
- Honours in natural science, and degree of B.A., will be attainable without Greek; not ordinary degrees, 5569, 5570, 5577, 5578.
- Not desirable to change title of degree at Cambridge when given for science; present B.A. degree sufficient, 5589, 5590.

Examinations.
- In "previous" examinations at Cambridge, natural science students will be allowed to take French and German instead of Greek; mathematics and Latin required, 5569, 5570, 5577, 5578.
- For ordinary degree candidates at Cambridge, Greek will be required, 5571, 5572.
- Candidates for all the four triposes at Cambridge are exempt from the general examination, 5573, 5574.

CLARK, Rev. W. G.—cont.

Fellowships.

Present holders of Cambridge fellowships need not suffer by taxation of colleges; some fellowships might be abolished or suspended, 5559.

Approval of consolidating Cambridge fellowships into professorships, 5564.

Objection to taxation of Cambridge non-resident fellowships, as bringing to University some undesirable persons, 5564.

All Cambridge non-resident fellowships should be terminable, and also fellowships where holders are not engaged in University work; seven years after M.A. degree would be a good time, 5564–5568.

Cambridge non-resident fellowships do not terminate at all where the holders take orders, provided they do not marry, 5566, 5567.

Fellows of Trinity who are tutors, lecturers, or bursars, retain their fellowships during office, and, if in office 10 years, for life, except they marry, 5567.

Greek.

In Cambridge "previous" examinations, French and German will be allowed to be taken instead of Greek; Latin indispensable, 5569, 5578.

Honours in natural science, degree of B.A., and government of University, will be obtainable at Cambridge without Greek; but not the ordinary degree, 5569–5584.

Heads of Colleges.

Masterships of colleges at Cambridge might be made more available; University workers should be elected; masters might teach; masterships might be combined with professorships, 5554–5556.

Income and Expenditure.

Cambridge professors should have larger salaries, 5551.

A per-centage on distributable income of colleges the best mode of raising funds for University purposes, 5552–5554.

To tax colleges, a commission, authorized by Act of Parliament, would be desirable, 5557–5559.

In taxing colleges at Cambridge, incomes of present holders of fellowships need not suffer, 5559.

Tendency of college incomes at Cambridge is to increase, though present revenue has diminished, 5560–5563.

Payments of Cambridge masters of arts form a great portion of University revenue, 5583.

Cambridge University income from landed property and Government stock is about 2,600*l.* a year; fees, &c. about 20,000*l.*; 2,000*l.* a year allowed for museums and general building funds; 1,500*l.* a year for museums' maintenance, which is too small, 5584.

Five per cent. taxation of colleges sufficient for present purposes; more might be imposed when needed, 5585, 5586.

Languages.

French and German, instead of Greek, will be allowed to be taken by science students at Cambridge; Latin indispensable, 5569–5584.

Marriage.

Cambridge non-resident fellowships terminate on marriage, 5566, 5567.

Mathematics.

Cambridge natural science students will have to pass in first three books of Euclid, elementary algebra, arithmetic, &c., 5577.

Parliament.

A commission, authorized by Act of Parliament, would be desirable for taxing colleges at Cambridge; provision for further taxation should be made, 5557–5559, 5586.

Professors.

Additional professors are wanted at Cambridge University; existing professors should have larger salaries, 5551.

Desirable that masters of colleges at Cambridge should be chosen from professors; mastership might be made a retiring pension for professors, 5554, 5555.

A five per cent. college taxation at Cambridge would be sufficient to establish and maintain a professoriate for the present, 5585, 5586.

Professorships.

Masterships of colleges at Cambridge might be combined with professorships, 5556.

Approval of consolidating fellowships into professorships, 5564.

Religion. See *Clergymen.*

CLARK, Rev. W. G.—cont.

Saint John's College (Cambridge).

St. John's College non-resident fellowships terminate seven years after taking M.A. degree; approval of this plan, 5565.

Science.

Promotion of science at Cambridge University; much has been done, but further steps must be taken, 5546–5591.

Students.

Cambridge students of natural science will be able to take honours and B.A. degree without knowing Greek. 5569, 5570, 5577, 5578.

Honour students of Cambridge natural sciences' tripos would come into government of college, 5578–5582.

Superannuation.

Masterships of colleges at Cambridge might be made available as retiring pensions for professors, 5554.

Trinity College (Cambridge).

Trinity College, Cambridge, agreed to the proposed five per cent. taxation for University purposes, 5552.

Present sacrifice of revenue made by Trinity College, with a view to future advantage, 5561–5563.

Non-resident fellowships at Trinity College terminate seven years after taking M.A. degree, approval of this, 5565.

Trinity College fellows (not in holy orders), being tutors, lecturers, or bursars, hold their fellowships during office, and, after 10 years of office, for life, provided they do not marry, 5567.

At Trinity College there are 16 or 17 tutors and lecturers, 5588.

PHELPS, Reverend ROBERT, D.D. (Index of his Evidence.)

Accommodation for Science Purposes.

Chemical laboratory, built by Sidney Sussex College, Cambridge, 5596.

Assistant Professors, Lecturers, and Teachers.

Terminable fellowships at Cambridge would induce inferior lecturers; under present system first-rate men are attainable, 5628–5648.

Colleges at Cambridge could provide demonstrators, &c. for themselves, if needed, 5654.

Botany.

Teaching of botany at Sidney Sussex College, Cambridge; open to all members of University, 5596, 5657, 5658.

Cambridge University.

Colleges at Cambridge; combination for science teaching; injustice of taxing colleges for support of University; college funds are properly administered, and more useful to education as they are; if colleges are taxed, it should be upon dividends, not upon distributable revenue; inferior college tutors would result from terminable fellowships; collegiate instruction preferable to professorial, 5592–5665.

Cambridge fellowships; undesirable to tax non-resident fellowships; objection to consolidation, extinction, limitation, or diminution in value, of fellowships; marriage restriction no detriment to fellowships, 5594, 5626–5648.

Funds at Cambridge; funds for University are not urgently needed; University might tax its own members; taxation of colleges would be unjust; collegiate and University members might be taxed equally, 5604–5606, 5613–5620, 5624–5626, 5653–5665.

Cambridge professors; should pursue research, and not give elementary instruction; professors' salaries are inadequate, 5606–5613, 5653–5665.

Religion at Cambridge; collegiate teachers should be chiefly in holy orders; the clerical element is not oppressive, 5636–5644, 5649, 5651, 5652.

Cambridge professorships; consolidation of fellowships into professorships not to be recommended, 5648.

Objection to changing the collegiate system at Cambridge into a central University system, for any kind of instruction whatever, 5653–5665.

See *Sidney Sussex College (Cambridge).*

Chemistry.

Chemical teaching at Sidney Sussex College, Cambridge; laboratory built; instruction open to students of any college, 5596–5598, 5601–5603.

The professor of chemistry at Cambridge has to give elementary instruction, which is objectionable, 5607–5609.

Clergymen. See *Religion.*

Phelps, Rev. R.—cont.

Education.

The education of a clergyman cannot be too liberal, 5651, 5652.

Objection to changing the collegiate system at Cambridge into a central University system, for any kind of instruction whatever, 5653–5665.

Fellowships.

Fellowship for natural science given by Sidney Sussex College, Cambridge, 5594.

Fellowships at Sidney Sussex College, Cambridge, are worth about 250*l.* a year; there are nine fellowships, all being equal, 5626.

Undesirable to tax non-resident more than resident fellows at Cambridge, 5627.

Objection to terminable fellowships at Cambridge, as inducing an inferior class of teachers, 5628–5648.

Restriction of marriage no detriment to Cambridge fellowships, 5635, 5636.

Consolidation, extinction, limitation, or diminution in value of Cambridge fellowships, not to be recommended, 5648.

Income and Expenditure.

Additional funds may be desirable at Cambridge University, but are not urgently needed, 5604–5606.

Professors' salaries at Cambridge are inadequate, 5613.

Cambridge University might raise funds by taxing its own members, 5614.

Collegiate taxation at Cambridge would be most unjust; college funds are honestly administered, and more useful to education than if transferred to University, 5615–5617, 5625, 5653–5665.

Members of colleges at Cambridge, equally with members of University, might be taxed, the teaching being open to all; future members might perhaps contribute more, 5618–5620.

17*s.* a year is imposed on all members of Cambridge University; it might be 1*l.*, which would bring in nearly 10,000*l.* a year, 5624.

If colleges at Cambridge have to furnish funds, taxation should be based upon dividends, not distributable revenue, 5625, 5626.

Fellowships at Sidney Sussex College, Cambridge, are worth about 250*l.* a year, 5626.

Not desirable to tax non-resident more than resident fellows at Cambridge, 5627.

Laboratories.

Chemical laboratory established at Sidney Sussex College, Cambridge; open to pupils from any college, 5596.

Marriage of Fellows.

Restriction of marriage no detriment to Cambridge fellowships, 5635, 5636.

Original Research.

Original research the most important function of a University professor, 5606–5611.

Phelps, Rev. R.—cont.

Professors.

A University professor's function should not be mainly teaching; he should represent his science, have leisure for research, and not give elementary instruction 5606–5611.

Professor of chemistry at Cambridge has to give elementary instruction, which is objectionable, 5607–5609.

Professors of mathematics at Cambridge devote themselves to advanced teaching, 5611.

Salaries of Cambridge professors are inadequate, 5613.

At Cambridge, better results would ensue from collegiate than from professorial instruction, 5653–5665.

Cambridge professors' lectures should be given only to classes well prepared in colleges, 5655.

Professorships.

Consolidation of Cambridge fellowships into professorships is not to be recommended, 5648.

Religion.

For colleges like those at Cambridge, most of the teaching body should be in holy orders, 5636–5641.

In Sidney Sussex College, Cambridge, half the fellows are exempt from taking holy orders; similar liberty might obtain in other colleges, 5642–5644.

The clerical obligation is not oppressive at Cambridge University, 5643.

Education of members for the Church was the object of the foundation of Sidney Sussex College, Cambridge, 5649.

The education of a clergyman cannot be too liberal, 5651, 5652.

Scholarships.

Scholarships for natural science given by Sidney Sussex College, Cambridge; advertised annually, 5600.

Science.

Promotion of science by Sidney Sussex College, Cambridge, 5592–5666.

Sidney Sussex College (Cambridge).

Fellowship for natural science given by Sidney Sussex College, Cambridge, 5594.

Combination of Sidney with other colleges for teaching natural science, 5596.

Chemistry teaching at Sidney Sussex College; chemical laboratory built; teaching open to students of any college, 5596–5598, 5601–5603.

Natural science scholarships given by Sidney Sussex College, Cambridge; advertised annually, 5600.

Sidney Sussex College was founded to educate its members for the Church, 5649.

Students.

Sidney Sussex College, Cambridge, would recognize distinguished students of natural science; the rewards are advertised yearly, 5595, 5599.

Chemical lectures and laboratory at Sidney Sussex College, are open to students of all colleges, 5596–5598.

ANALYSES OF THE EVIDENCE

RESPECTING THE

NATIONAL SCIENTIFIC MUSEUMS AND COLLECTIONS,

REPORTED ON IN FOURTH REPORT.

JONES, JOHN WINTER, Esq. (Index of his Evidence.)

Admiralty Surveys. See *Government Survey Expeditions.*

Artizans.
Saturday afternoon visits of artizans to British Museum; special explanations given; successful result, 6501, 6505, 6506.

Botany.
Increase of students in botanical department of British Museum; 1,041 last year, 6578.

British Museum.
Officers of British Museum; principal librarian has charge of all the collections; impossible for officers to lecture while acting as curators, 6488–6498, 6503, 6505, 6506, 6556–6558, 6562–6566.
Trustees of British Museum; those who manage the natural history department are sufficient for the purpose, 6491, 6502, 6507–6519, 6583–6586.
Appointments in British Museum; approval of present system, 6491, 6562–6566.
Natural history collections in British Museum; duplicates may be sold or exchanged; Museum could not send out collections for circulation; objection to specimen cases which open at the back 6492–6498, 6502, 6504, 6534–6546, 6552–6561, 6567–6574, 6580–6582.
Library of British Museum; formerly its principal feature; successful exclusion of dust from cases in library, 6541.
Catalogues of British Museum; interesting series on natural history, but no "catalogue raisonnée;" superintendent of natural history edits and is responsible for the catalogues, 6494, 6496, 6497, 6520–6526.
Visitors to British Museum; visitors would not be many if Museum were open on Sunday; Museum has been opened in the evenings; visitors not numerous; accessible at all times to foreigners; Saturday afternoon visits of working men, 6498–6503, 6533, 6547–6551, 6575–6579.
Lectures in British Museum; could not be given by officers, except in way of explanation to small parties, 6503, 6505, 6506, 6556–6558.
Detailed labels would be of use to a certain extent in the British Museum, 6560, 6561.
Difficulties with respect to dust in British Museum; they may be surmounted (as shown in library), but the process is expensive, 6540–6546, 6549.
Objects obtained in Government Surveys are mostly sent to the British Museum, 6569, 6570, 6574.

Canterbury, Archbishop of.
The Archbishop of Canterbury is one of the official trustees who appoint British Museum officers, 6491, 6562–6566.

Catalogues.
British Museum natural history catalogues; interesting series; no "catalogue raisonnée;" superintendent of natural history department is the editor of, and responsible for, the catalogues; Dr. Gray edits the zoological catalogues, 6494, 6496, 6497, 6520–6526.

Chancellor, Lord.
The Lord Chancellor is one of the official trustees who appoint British Museum officers, 6491, 6562–6566.

Directors, Curators, &c. of Museums. See *British Museum.*

Duplicate Specimens in Museums. See *British Museum.*

JONES, J. W., Esq.—cont.

Dust in Museums.
Injury to museums from dust; successful exclusion of dust from British Museum library cases; remedy expensive, 6540–6546, 6549.

Evening Exhibitions.
British Museum has been opened on Saturday and Monday evenings; visitors have not been numerous, but more may come when the fact is better known, 6575–6579.

Geology.
818 students visited the geological department of the British Museum last year, 6578.

Gray, Dr.
The zoological catalogues of the British Museum are edited by Dr. Gray, 6522, 6523.

Labels in Museums.
Detailed labels at the British Museum would be of use to a certain extent, 6560, 6561.

Lectures.
British Museum officers have no time to lecture upon the collections; they might give occasional explanations to small parties, as has been done in the case of working men, 6501–6506.

Library of the British Museum.
When the British Museum was established the library was the principal feature, and the chief officer of the institution was called principal librarian, 6492.
Special cases in British Museum library for keeping out dust; successful, but expensive, 6541.

Magellan Straits' Expedition. See *Survey Expeditions.*

Mineralogy.
Many duplicate specimens in British Museum department of mineralogy, 6493, 6571.

Museums.
Objection to provincial museums being supplied with specimens by British Museum, 6504.
Great injury to museum specimens from dust; the remedy is successful, but expensive, 6540–6546, 6549.
See *British Museum.*

Natural History Collections. See *British Museum.*

Owen, Professor.
Professor Owen appointed superintendent of natural history departments at British Museum in 1856, 6494.
See *British Museum.*

Speaker of the House of Commons.
The Speaker is one of the official trustees who appoint British Museum officers, 6491, 6562–6566.

Students.
For admission to British Museum collections, students have to apply to the principal librarian, 6498–6500.
Necessary, for sake of students, that British Museum, should not be open every day, 6533.
Special register of students' visits is kept in the British Museum, 6578, 6579.

Sundays.
Objection to opening British Museum on Sundays; people would not care to visit it; accumulation of dirt would be serious, 6547–6551.

JONES, J. W., Esq.—cont.

Survey Expeditions.
Objects obtained in Government Surveys are mostly sent to the British Museum, 6569, 6570, 6574.
Specimens received by British Museum from the Magellan Straits' Expedition, 6569, 6570, 6574.

Trustees of British Museum. See *British Museum.*

Visitors to Museums. See *British Museum.*

Zoology.
The zoological catalogues of the British Museum are edited by Dr. Gray, 6522, 6523.

OWEN, PROFESSOR RICHARD, M.D., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
Natural history museum, covering three acres, lately built at Massachusetts, 6597.
See *British Museum.*

Agassiz, Professor.
Extensive natural history museum at Massachusetts, founded on plan of Professor Agassiz, 6597.

Anatomy.
Lectures on comparative anatomy given at the Hunterian Museum, 6590.

Artizans.
Occasional lectures given in British Museum to artizans; success of the system, 6595–6597.

Botany.
Free elementary lectures on recent and fossil botany might be given at the British Museum, 6593, 6613, 6641, 6642.

British Association.
Address to British Association, in which the practice of museum curators giving explanatory lectures is recommended, 6597.

British Museum.
Officers of British Museum; curators should give explanatory lectures on the objects under their care, 6592–6602, 6609–6611, 6613, 6616, 6641, 6642.
Accommodation for British Museum natural history department; lecture room proposed; general approval of South Kensington plan, 6592, 6593, 6597, 6603–6605, 6620–6640.
Natural history collections at British Museum; crowded state; great space wanted for the large animals; increase of specimens; desirable if duplicate specimens could be furnished to other museums, 6592–6594, 6620–6631, 6634, 6643–6655.
Lectures at the British Museum; desirable that short courses should be given; new building at South Kensington should have a theatre for this purpose; 6593–6602, 6609, 6611, 6613, 6616, 6618, 6641, 6642.
Visitors to British Museum; special visits of professors with their classes, and of artizans, &c., 6595–6597.

Catalogues.
Hunterian Museum catalogues of fossil remains, osteology, &c., compiled by Professor Owen, 6587–6591.

Carruthers, Mr.
Mr. Carruthers' general approval of South Kensington plans for British Museum; but space barely sufficient, 6604.

Conchology.
Free lectures on conchology might be given at the British Museum, 6593, 6613, 6641, 6642.

Directors, Curators, &c. of Museums. See *British Museum.*

Duplicate Specimens. See *Natural History Collections.*

Entomology.
Free elementary lectures on entomology might be given at the British Museum, 6593, 6613, 6641, 6642.

Ethnology.
Ethnology might be explained in free elementary lectures at the British Museum, 6593, 6613, 6641, 6642.

Evening Exhibitions.
If British Museum natural history collections be removed to South Kensington, the proposed type museum might be lighted in the evening, 6601.

Geology.
Free elementary lectures on geology might be given at the British Museum, 6593, 6613, 6641, 6642.

Gray, Dr.
Dr. Gray's report on want of space for British Museum natural history collections, 6593.
General approval by Dr. Gray of South Kensington plans for British Museum natural history collection; but space barely sufficient, 6604.

OWEN, Professor—cont.

Herpetology.
Free elementary lectures on herpetology might be given at the British Museum, 6593, 6613, 6641, 6642.

Hunterian Museum.
Hunterian Museum, purchased by Parliament in 1799; confided to Royal College of Surgeons. Professor Owen formerly curator and professor, 6587–6591, 6639.

Ichthyology.
Free elementary courses of lectures on ichthyology might be given at the British Museum, 6593, 6613, 6641, 6642.

Income and Expenditure.
British Museum curators, &c., if they gave lectures, should have increased salary, 6600.

Lectures.
Lectures, by Professor Owen, on comparative anatomy, at the Hunterian Museum, 6590.
See *British Museum.*

Lighting Museums. See *Museums.*

Malacology.
Free elementary lectures on malacology might be given at the British Museum, 6593, 6613, 6641, 6642.

Mammalogy.
Keepers of British Museum might give free elementary lectures on mammalogy, 6593, 6613, 6641, 6642.

Maskelyne, Professor.
Professor Maskelyne's general approval of South Kensington plans for British Museum; but space barely sufficient, 6604.

Massachusetts.
Museum of natural history at Massachusetts, lately built on a scale similar to that proposed by Professor Owen, 6597.

Mineralogy.
Free elementary lectures on mineralogy might be given at the British Museum, 6593, 6613, 6641, 6642.

Museum of Practical Geology.
Approval of lighting museums at the angle between the roof and side wall, as in Jermyn Street Museum, &c., 6639.

Museums.
Extensive museum of natural history lately erected at Massachusetts, 6597.
Approval of lighting museums at the angle between the roof and side wall, as at Royal College of Surgeons and Jermyn Street Museum, 6639.
Local museums are of great use in fostering a taste for science, 6643.
Local museums might be furnished with specimens by British Museum.
See *British Museum.*

Natural History Collections. See *British Museum.*

Ornithology.
Short elementary courses on ornithology might be given at the British Museum, 6593, 6613, 6641, 6642.

Owen, Professor.
Professor Owen; catalogues compiled and lectures given by him at the Hunterian Museum, 6587–6591.
See *British Museum.*

Palæontology.
Free elementary lectures on palæontology might be given at the British Museum, 6593, 6613, 6641, 6642.

Parliament.
Opposition of Parliament to proposed plan for the British Museum natural history collections, 6597.

Professors.
Professors' classes visit the British Museum, to have oral instruction from the keepers, 6595–6597.

Royal College of Surgeons. See *Hunterian Museum.*

Royal Institution.
Lecture on British Museum natural history collections given at the Royal Institution; five acres of ground stated to be requisite for the collections, 6953.

Schools.
Advantage to teachers of schools of having short courses of lectures given to them at the British Museum, 6597, 6609–6611, 6618.

Science.
Advantage of local museums in view of promoting a taste for science, 6643.

OWEN, Professor—cont.

South Kensington.
General agreement of British Museum keepers of natural history with the plans proposed for a museum at South Kensington, but space considered insufficient; type museum proposed, which can be used as a lecture theatre, and lighted in the evening, 6603–6605, 6620-6640.

Students.
Explanations to classes of students given in British Museum by the keepers, 6595–6597.

Teachers.
Natural history lectures given at the British Museum would be valuable to teachers of schools, 6597, 6609–6611, 6618.

"The Times."
Letter to "The Times," in opposition to Professor Owen's scheme for the natural history collections, 6597.

Waterhouse, Mr.
Mr. Waterhouse's general approval of South Kensington plans for British Museum; but space barely sufficient, 6604.

Zoophytology.
Free elementary lectures on zoophytology might be given at the British Museum, 6593, 6613, 6641, 6642.

HOOKER, JOSEPH D., Esq., M.D., C.B. (Index of his Evidence.)

Accommodation for Science Purposes. See *Kew Gardens.*

Boards of Visitors.
A board of visitors, with power of recommendation to First Commissioner of Works, might be desirable for Kew Gardens, 6692–6694, 6711 6713.

Botany.
Most of the botanical societies in different parts of the world are in communication with Kew Gardens, 6671.
Provincial museums might be furnished by Kew with botanical duplicates, if application could be made at the right time, 6674–6679.
A typical, not a general, herbarium, might be valued in populous districts, 6679.
See *Kew Gardens.*

British Museum.
Kew Museum and British Museum are competing bodies; this should not be, 6660, 6661, 6680–6688.
If British Museum botanical collections be removed to South Kensington, the palæontological portions should remain there, with a good herbarium; geographical arrangement desirable, 6681–6688, 6730–6747.
British Museum system of management by trustees would not be applicable to Kew Gardens, 6691–6696.
If British Museum natural history collections be removed to South Kensington, they should, after re-classification, be placed under one director, responsible to the Crown; Government might appoint visitors, 6703–6714, 6748–6758, 6764–6768.
Zoological collections of the British Museum are the finest in Europe, 6767.

Directors, Curators, &c. of Museums. See *Kew Gardens.*

Dust in Museums.
Dust accumulations on museum specimens is less at Kew than in London; a grass area and trees will decrease dust, 6721–6725.

Geology.
For the sake of geologists, the British Museum fossil botany collections should remain near London, 6683.

Government.
Director of Kew is immediately responsible to the First Commissioner of Her Majesty's Works, 6689.
The South Kensington natural history museum should be placed under a director, responsible to Government; Government might appoint a board of visitors, 6703–6714, 6748–6758.

Greenwich Observatory.
A board of visitors, like the visitors to the Royal Observatory, might be desirable for Kew Gardens, &c., 6693–6696, 6711–6713.

Income and Expenditure.
Curator of museums at Kew has 150*l.* a year; keeper of herbarium and library, 400*l.* and a house, 6664.

Kew Gardens.
Scientific officers at Kew Gardens comprise director, curator of museums, keeper of herbarium and library, two assistants, and a clerk, 6657, 6664, 6689–6696.
Library at Kew is entirely a library of botanical reference, 6668, 6669.

HOOKER, J. D., Esq.—*Kew Gardens*—cont.
Herbarium at Kew; furnishes materials for publication of botanical works; herbarium should be fire-proof, 6658, 6680, 6701, 6702.
Kew Museum and British Museum are competing bodies; they should have separate functions, but be under one system, 6660, 6661, 6681–6688, 6730–6747.
Government Survey collections are mostly sent to Kew, 6660.
Museums at Kew; three museums; arranged scientifically, according to natural system; no competition between the industrial museum at Kew and South Kensington, 6662, 6663.
Lectures should not be given by the officers at Kew, 6665, 6697–6700.
Kew might supply duplicates, if application were made at the right time; this could be accomplished by inspection of museums; duplicates are distributed as fast as possible, 6674–6677, 6728.
Kew Gardens should not be governed by trustees, but by a director and a board of visitors; appointments should be made by director, 6689–6696, 6711–6713.
When British Museum natural history collections are removed to South Kensington, they should be placed under a system of management similar to that of Kew Gardens, 6703–6714, 6748–6758.
Accumulation of dust less at Kew than in London; grass area and trees will lessen amount of dust, 6721–6725.

Labels in Museums.
The labels at Kew give interesting information, 6667.

Lectures.
Curators of Kew and British Museum should not lecture, 6665, 6697–6700, 6715, 6716, 6750.

Libraries.
The library at Kew is entirely a library of botanical reference, 6668, 6669.

Museums.
Continental museums contribute to the Kew herbarium, 6658.
See *Kew Gardens.*

Natural History Collections.
Approval of natural history specimen cases which are hermetically closed in front to the public, and accessible to working naturalists at the back, 6717–6727.
Dust accumulation on natural history specimens less at Kew than in London; grassed area and trees desirable to decrease dust, 6721–6725.
See *Kew Gardens, &c.*

Palæontology.
British Museum palæontological collections should remain near London; when removed to South Kensington, fossil plants should be connected with botanical department, and be divided from fossil animals, 6681-6688, 6730–6747.

South Kensington.
No competition between South Kensington Museum and industrial museum at Kew, 6663.
British Museum botanical collections at South Kensington should comprise fossil botany and a herbarium, which herbarium, together with that of Kew, should be under one arrangement and management, 6681–6688, 6730–6747.
The British Museum natural history collections, when at South Kensington, should be under one director, responsible to the Crown, who should appoint visitors, 6703–6714, 6748–6758.

Students.
There are annually 12 or 14 foreign students of botany at Kew, who work and stay for some time, 6673.

Survey Expeditions.
Collections made by Government Surveys are mostly sent to Kew, 6658, 6660.

Zoology.
The British Museum zoological collections are the finest in Europe, 6767.

SCLATER, PHILIP LUTLEY, Esq., Ph.D., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes. See *British Museum.*

Boards of Visitors.
For the new natural history museum at South Kensington a board of visitors would be desirable; the board should comprise nominees from scientific societies, 6774.

SCLATER, P. L., Esq.—cont.

Botany.

Unfortunate for botany that palæontology has been considered a distinct science, 6814–6823.

British Museum.

Trustees of British Museum; objection to the system of government, 6771.

British Museum natural history collections are suffering from the want of having a proper administrative head, and from an inadequate staff, 6771, 6772, 6824.

Objection to British Museum being available only two or three days a week for scientific work, 6779.

Library of British Museum; difficult for Museum students to get books; evil of separating Museum and library made too much of, 6783.

For teaching purposes, the great natural history collections of the British Museum are not necessary, 6795, 6796.

Mounted, osteological, and spirit specimens in British Museum ought to be amalgamated; College of Surgeons' collection of dissected soft parts might be added, 6802–6813.

Insufficiency of sum allowed for zoological acquisitions at British Museum, 6829.

Inadequate accommodation at British Museum for scientific staff and students, 6830, 6831.

Large number of British Museum specimens derived from Zoological Gardens, 6832.

Duplicates at British Museum; all specimens registered; supposed not to leave Museum; fewer duplicates than generally believed; series of specimens of each species requisite, 6832–6837.

Desirable if British Museum could publish descriptions of important acquisitions, but scientific societies do this work, 6838–6842.

See *South Kensington.*

Catalogues.

Catalogues of British Museum; some have been illustrated with woodcuts borrowed from Zoological Society, 6840.

Civil Service Examinations. See *Examinations.*

College of Surgeons. See *Hunterian Museum.*

Council of Scientific Advice.

A minister of education might be assisted by a council of scientific advice, 6775–6778.

Directors, Curators, &c. of Museums. See *British Museum, Kew, South Kensington.*

Entomology.

Great want of curators in British Museum entomological department, 6824.

Examinations.

Officers for a natural history museum could not be obtained under the ordinary civil service rules, 6773.

Geology.

In new natural history museum at South Kensington there should be a palæontological gallery, exhibiting the fauna in each epoch, 6822.

Government.

The South Kensington natural history museum should be controlled by a director immediately responsible to Government, 6770–6778.

Approval of management of Kew Gardens, director being responsible to Government, 6776–6778.

Government should arrange for the amalgamation of the Hunterian Museum with the British Museum natural history collections, 6806–6813.

Government is aided by scientific societies; science should be aided as much as possible by Government, 6838–6842.

Greenwich Observatory.

A board of visitors, similar to Royal Society visitors to Royal Observatory, desirable for new natural history museum at South Kensington, 6774.

Hunterian Museum.

Lectures at the Royal College of Surgeons, illustrated by contents of Hunterian Museum, 6784–6786.

The Hunterian collection of dissected soft parts might be amalgamated with the British Museum collections, 6802–6813.

The Hunterian Museum has become a burden to the College of Surgeons, 6806–6808.

Income and Expenditure.

Sum allowed for zoological acquisitions at British Museum is quite inadequate; Museum is always in debt for specimens, 6829.

SCLATER, P. L., Esq.—cont.

Jardin des Plantes (Paris).

Advanced teaching by professors in the Jardin des Plantes, 6787.

Important discoveries brought to light by the publications issued from the Jardin des Plantes, 6838.

Kew Gardens.

Approval of Kew system of having a director responsible to Government, 6776–6778.

Lectures.

Lectures should be given at the new South Kensington natural history museum, but not necessarily by the curators, 6784–6797.

Lectures at the Royal College of Surgeons and Jardin des Plantes; advanced instruction given, 6785–6787.

Libraries.

Libraries are necessary appendages to museums, 6783.

New South Kensington natural history museum should have a special working library in each department, and also a large central library, 6783.

The evils of separating British Museum natural history collections and library have been exaggerated, 6783.

Lighting Museums. See *South Kensington.*

Metropolitan College of Science (proposed).

At South Kensington, lectures would be better given in the new college of science than in the new natural history museum, 6793.

Minister of Education.

Minister of education (when appointed) should have charge of South Kensington natural history collections; he might be assisted by a council of scientific advice, 6775–6778.

Natural History Collections.

Natural history specimens should be arranged in hermetically sealed glass cases, opening at the back into students' rooms, 6780.

For teaching purposes, a simple collection of natural history specimens would alone be necessary, 6795.

A workable collection of zoology may be packed in a smaller space than might be supposed, 6798.

Duplicate natural history specimens; a national museum should have a series of specimens of each species, 6832–6837.

See *British Museum, South Kensington, &c.*

Ornithology.

More than one man's work to understand systematic ornithology; a curator of ornithological specimens would not have time to lecture, 6790, 6791.

About 30,000 birds in British Museum, 6798.

Palæontology.

Extinct organisms should be amalgamated with living creations in the new natural history museum at South Kensington; a special palæontological gallery also desirable, 6814–6823.

Royal College of Surgeons. See *Hunterian Museum.*

Scientific Societies.

Nominees from scientific societies would form a good board of visitors for new natural history museum at South Kensington, 6774.

Desirable that British Museum should publish descriptions of important acquisitions; but scientific societies do this work, 6838–6842.

South Kensington.

New natural history museum at South Kensington should be under control of a director responsible to Government; appointments should be made by him, 6770–6778.

A board of visitors desirable for new natural history museum at South Kensington; these should be nominees from scientific societies, 6774.

New natural history museum at South Kensington should be placed under the Minister of Education (when appointed), or his present representative, the Lord President, 6775.

Cases opening at the back would be desirable in the new natural history museum at South Kensington, and a working library for each department, 6780–6783.

Desirable to have lectures in connexion with new South Kensington natural history museum; curators not necessarily teachers, 6784–6797.

Director of South Kensington natural history museum should be the best man obtainable; he should be appointed at once, and be consulted in all matters pertaining to the new museum, 6799–6801, 6824–6828.

In the new South Kensington natural history museum palæontological and living creations should be amalgamated; a palæontological gallery also desirable, 6814–6823.

See *British Museum.*

Sclater, P. L., Esq.—cont.

Students.
Disadvantage to students of British Museum being open only two or three days a week for scientific study, 6779.
Advantage to students in museums of specimen cases opening at the back into private rooms, 6780.
Want of accommodation for students in the British Museum, 6831.

Zoological Society.
Large number of British Museum specimens derived from Zoological Gardens, 6832.
Woodcuts of the Zoological Society used for British Museum catalogues, 6840.

Zoology.
Unfortunate for zoology that palæontology has been considered a distinct science, 6814–6823.

FLOWER, **Professor**, F.R.S. (Index of his Evidence.)

Anatomy.
Anatomy has been hitherto too much divorced from zoology, 6852.
For anatomy and physiology, but not for zoology, the College of Surgeons' Museum is a good introduction, 6853.
A complete anatomical collection, arranged zoologically, should be the aim of the new South Kensington natural history museum, 6853.

British Museum.
Objection to the two separate zoological arrangements of recent and fossil animals at the British Museum, 6845, 6851.

Directors, Curators, &c. of Museums.
Curators at new natural history museum at South Kensington would derive advantage from the practice of giving lectures there, 6856–6859.

Evening Exhibitions.
With cases closed in front, the new natural history museum at South Kensington might be lighted up in the evening, 6845.

Geology.
A separate geological collection might be desirable in the new natural history museum at South Kensington, 6847–6852.

Government.
Maintenance of College of Surgeons' Museum might be undertaken by Government, which has already contributed 57,500*l.*, 6874.

Hunterian Museum.
Hunterian Museum a good introduction to anatomy and physiology, but insufficient for zoologists, 6853.
Objection to moving Hunterian Museum to South Kensington, on account of medical students, 6854, 6855, 6860–6868.
Maintenance of College of Surgeons' Museum costs about 2,500*l.* a year, 6869–6873.
Government might maintain the College of Surgeons' Museum; the nation has already contributed to it, 6874.

Income and Expenditure.
About 2,500*l.* a year spent in maintaining College of Surgeons' Museum; 57,500*l.* has been contributed to the Hunterian Museum, &c. by the nation, 6874, 6869–6873.

Kew Gardens.
Detailed labels (like those at Kew Gardens) would be desirable for the new natural history museum at South Kensington, 6845.

Labels in Museums.
New natural history museum at South Kensington should have legible detailed labels, 6845.

Lectures.
Officers at new natural history museum at South Kensington should give lectures; advanced instruction should be given, 6856–6859.

Medicine.
The College of Surgeons is convenient for medical men at the hospitals; great objection to its removal to South Kensington, 6853–6855, 6860–6868.

Natural History Collections.
Facilities for getting natural history specimens are much greater than formerly, 6866.
See *British Museum*, &c.

Flower, Prof.—cont.

Palæontology.
New natural history museum at South Kensington should have the palæontological specimens in the zoological galleries; there might also be a separate geological collection, 6847–6852.

Physiology.
College of Surgeons' Museum affords a good introduction to anatomy and physiology, but not to zoology, 6853.

Royal College of Surgeons. See *Hunterian Museum.*

Science.
Anatomy has been hitherto too much divorced from zoology, 6852.

South Kensington.
The new natural history museum proposed for South Kensington should be open all day and every day, 6845.
Natural history collections in new museum at South Kensington should not be too numerous; they should have cases sealed in front, and detailed labels; zoological arrangement desirable, 6845, 6847, 6852, 6853.
Objection to distinct palæontological department in new South Kensington natural history museum, but not to a separate stratigraphical collection, 6847–6852.
Museum of Royal College of Surgeons should not be moved to South Kensington, but might be under same superintendence as new natural history museum, 6854, 6855, 6860–6868.
Curators at new natural history museum at South Kensington should give lectures; advanced instruction should be given, 6856–6859.

Students.
Medical students could not use the College of Surgeons' Museum if it were removed to South Kensington, 6853–6855, 6860–6868.

Zoology.
Anatomy has been hitherto too much divorced from zoology, 6852.
A good introduction to anatomy and physiology, but not zoology, is afforded by the College of Surgeons' Museum, 6853.
A complete anatomical collection, arranged zoologically, should be the aim of the new natural history museum at South Kensington, 6853.

BENTHAM, GEORGE, **Esq.**, F.R.S. (Index of his Evidence.)

Botany.
Two national botanical establishments desirable, in London and at Kew, working in harmony, but with different purposes, 7203–7211.

British Museum.
British Museum botanical department should be maintained, not in rivalry with Kew, but for a different purpose, 7203–7211.

Directors, Curators, &c. of Museums. See *South Kensington.*

Geology.
Keeper of botany in new museum at South Kensington should be a geologist, 7205–7210.

Kew Gardens.
Desirability of having a national botanical establishment in London as well as at Kew, 7203–7211.
Advantage of combining Kew and British Museum botanical collections; retaining at Kew all specimens of interest to scientific botanists, and returning to British Museum an herbarium of accurately named representative specimens, 7203–7211.
Desirability of adhering to the rule, that at Kew products should be arranged according to the plants they are derived from, and at South Kensington according to the uses they are put to, 7205, 7211.

Palæontology.
Botanical collection in new natural history museum at South Kensington should be partially subservient to vegetable palæontology, 7205–7208.

South Kensington.
A great botanical museum and herbarium should be connected with new natural history museum at South Kensington, for comparison and exhibition of plants; it should be clearly separated from the economic museums, 7203–7211.
Botanical collections in new natural history museum at South Kensington might be divided into typical and geographical, 7205.

Bentham, G., Esq.—cont.

An extensive and select library should accompany the botanical collection in the new natural history museum at South Kensington, 7205.

Keeper of botany in new museum at South Kensington should be a geologist and botanist; he should not be under direction of Kew, 7205–7210.

All collision between South Kensington and Kew economic botany collections should be avoided, 7205, 7211.

BALL, JOHN, Esq., F.R.S. (Index of his Evidence.)

Boards of Visitors.

British Museum trustees might be modified into a board of visitors for new natural history museum at South Kensington, 7225, 7226.

Directors, Curators, &c. of Museums.

Tendency of distinguished curators to let mechanical work of museums fall into arrear, 7217.

British Museum.

An herbarium, like that at the British Museum, should be in the metropolis, 7216.

Traditions of British Museum have not been favourable to botanical science, 7217.

Cultivators of science would like the Kew and British Museum botanical collections united, 7216.

Government of British Museum; natural history department should be under one superintendent, responsible to a minister; objection to trustees; they might become a board of visitors, 7219, 7221, 7225, 7226.

Connexion desirable between keeper of botanical collections at British Museum and director at Kew, 7220.

British Museum botanical collection is subservient to the geological collection, rather than to recent plants; fossil botany collection might remain where it is, 7220.

All botanical collections presented to British Museum should go first to Kew, for classification, 7231.

Botanical collections at Kew might be made available to complete the British Museum collections, 7232.

Council of Scientific Advice. See *Government.*

Geology.

Function of British Museum botanical collection is subservient to the geological collections; this system might remain, 7220.

Government.

British Museum should have a director responsible to Government, 7221, 7222.

In the Government there should be some permanent officer charged with the interests of science, 7222, 7233–7238.

Royal Society would not be the best scientific adviser of the Government, except in important matters; the society might point out competent advisers, 7223, 7224, 7233–7238.

Kew Gardens.

The Kew collections are the most valuable in the world, 7214–7220.

Union of Kew and British Museum botanical collections would be approved by cultivators of science, 7216.

Kew might send out correctly named duplicate specimens to British Museum, colonial institutions, and other centres, 7217, 7232.

There should be a connexion between the director of Kew and the keeper of the British Museum botanical collections, 7220.

All general botanical work should be done at Kew; naming and classification could be done quicker there than at the British Museum, 7227 7231.

Kew might be available for completion of the British Museum botanical collections, 7232.

Minister for Science.

Desirability of having a permanent Government officer charged with the interests of science, 7222–7224, 7233–7238.

Palæontology.

Department of fossil botany might remain at the British Museum, 7220.

Royal Society.

Council of Royal Society not the best scientific adviser of Government, except in important matters; society might point out competent advisers, 7223, 7224, 7233–7238.

Science.

There should be a permanent Government officer charged with the interests of science, 7222 7224, 7233 7238.

General ignorance of public men of what is going on in science, 7238.

THOMSON, THOMAS, Esq., M.D., F.R.S. (Index of his Evidence.)

British Museum.

Botanical collections of British Museum should be maintained, but should not be independent of Kew; some might go to Kew, 7239–7243.

British Museum should retain the fossil botany collection; this has not been attended to at Kew, 7244, 7245.

Directors, Curators, &c. of Museums.

If Kew be the head national botanical establishment, the British Museum botanical director should be subordinate to the director of Kew, 7243, 7247, 7248.

Government.

Government purchased the Kew collection; it was the property of Sir William Hooker, 7240.

Hooker, Sir William.

The Kew botanical collection was almost entirely a private collection of Sir William Hooker's, 7240.

Kew Gardens.

Kew Gardens collection only recently a Government collection, 7239, 7240.

Collection at Kew more available for scientific research than that at British Museum, 7242.

At Kew should be the main botanical collection of the nation, 7243.

Botanical collections of Kew and British Museum should be correlated, and work in unison; one should be the head, the other the branch, 7243, 7247, 7248.

Department of palæontology has not been attended to at Kew, 7244, 7245.

Palæontology.

Palæontological department has never been attended to at Kew; it should remain with the British Museum, 7244, 7245.

MASKELYNE, NEVIL S., Esq., M.A. (Index of his Evidence.)

Accommodation for Science Purposes. See *British Museum.*

Boards of Visitors.

Royal Observatory board of visitors a good model for a board for British Museum, 7451, 7483–7498.

British Museum.

Government of British Museum, when re-constructed, should contain a larger scientific element; it might perhaps be governed by a council of keepers, with superintendent as chairman, responsible to the Crown, 7453, 7454.

Objection to trustees of British Museum; they should act as a board of visitors; nine would be sufficient, 7454, 7483 7498.

Director of British Museum should be responsible to Government; not important whether museum is under a single director or not, 7454, 7501.

Appointment of keepers at British Museum should be made by the Crown; subordinate appointments should be temporary at first, and emanate from keepers; higher offices are mostly filled by promotion from lower ones, 7455 7459, 7499, 7503, 7512–7518.

Archbishop of Canterbury, Speaker, and Lord Chancellor, appoint to every office in British Museum, 7456.

Lecture-room not desirable at British Museum; objection to keepers lecturing; they might occasionally take a class round the museum, 7460–7462.

Students at British Museum; museum mainly exists for students; tendency of regulations to keep them out; keepers should have authority to admit them, 7463–7466.

Approval of British Museum cases being sealed in front; entire case might be made to move upon wheels, 7467, 7468.

Evening opening of British Museum in summer; success not great; Sunday opening would attract crowds, 7469–7476, 7501 7511.

Approval of lighting up British Museum with gas; provision for lighting up should be made in new building, 7474, 7475.

Desirable if British Museum keepers could benefit other museums as well as their own; additional cost would be required, 7477 7481.

British Museum might be made much more useful to science than it is, 7482.

Universities and public schools' men are not attracted by inferior offices in British Museum, 7515, 7518.

Civil Service Commissioners examine, in most cases, candidates for lower offices in British Museum; examination not competitive, 7516, 7517.

Higher education of officers not sufficiently appreciated at the British Museum, 7518.

MASKELYNE, N. S., Esq.—cont.

Canterbury, Archbishop of.
The Archbishop of Canterbury is one of the appointing trustees in the British Museum, 7456.

Chancellor, Lord.
One of the appointing trustees in the British Museum is the Lord Chancellor, 7456.

Civil Service Commission. See *Examinations.*

Directors, Curators, &c. of Museums. See *British Museum.*

Evening Exhibitions.
Opening of British Museum on summer evenings; result not successful; new natural history museum at South Kensington should be lighted, 7469–7476, 7510, 7511.

Examinations.
Inferior appointments at British Museum are subject to Civil Service examination; not competitive, 7516, 7517.

Germany.
In Germany some museums are only open on Sunday; they are largely attended, 7508, 7509.

Government.
British Museum keepers should be appointed by a minister of the Crown, and be in direct communication with Government, 7454–7458.
In a board of visitors for British Museum, five might be appointed by scientific societies, and four by Government, 7498.

Greenwich Observatory.
Board of visitors of Royal Observatory a good model for a board for the British Museum, 7485, 7486, 7489.

Income.
Small emolument of British Museum keepers, assistants, &c., 7515, 7518.

Lectures.
At the British Museum, lectures should not be given by keepers; objection to specimens being used for lecturing purposes, 7460–7462.

Lighting Museums. See *Evening Exhibitions.*

Mineralogy.
Exchanges of minerals between British Museum and other museums would be desirable, 7477–7481.

Museums.
Scientific museums should be governed by scientific bodies, 7453.
Number of students, not general public, the true test of museums' usefulness, 7463.
Some museums in Germany are open only on Sunday; they are largely attended, 7508, 7509.
See *British Museum.*

Natural History Collections.
Valuable specimens in museums should not be used for lecturing purposes, 7461.
Approval of cases sealed in front for natural history specimens; entire case might move out upon wheels, 7467, 7468.
See *British Museum.*

Royal School of Mines.
School of Mines' students used to visit British Museum; falling off attributable to British Museum regulations, 7464, 7465.

Schools.
Men from public schools are not attracted by inferior appointments in British Museum, 7515, 7518.

Science.
A scientific museum should be governed by a scientific body, 7453.

Scientific Societies.
Presidents of certain scientific societies should be included in a board of visitors for British Museum, 7490–7498.

South Kensington.
In new natural history museum at South Kensington provision should be made for lighting up in the evening, 7475.
Objection to South Kensington as a locality for the British Museum natural history collections, 7483.
See *British Museum.*

Speaker of the House of Commons.
The Speaker is one of the appointing trustees in the British Museum, 7456.

Students.
British Museum regulations tend to keep out students; number of students the true test of its usefulness, 7463–7466.

MASKELYNE, N. S., Esq.—cont.

Sunday.
British Museum would be crowded if opened on Sunday; no practical difficulty in opening it on that day, 7471, 7472, 7476, 7504–7509.
Museums in Germany, in some instances, are only open on Sunday; they are largely attended, 7508, 7509.

Universities.
University men not attracted by inferior appointments at British Museum, 7515, 7518.

Visitors to Museums.
Number of students, not general public, the true test of a museum's usefulness, 7462.
If British Museum were opened on Sundays, it would have a good effect on visitors, 7471, 7472, 7476, 7504–7509.

EGERTON, SIR PHILIP DE MALPAS GREY, BART., M.P. (Index of his Evidence.)

British Museum.
The British Museum is governed in the most admirable manner, 7523.
Trustees of British Museum; vacancies should be filled by men of science; objection to presidents of scientific societies being trustees, 7524, 7534–7541, 7559, 7565, 7566.
Appointments at the British Museum are made by the three principal trustees; approval of the system; objection to system of appointment to subordinate offices in natural history department, 7525, 7526, 7542–7546.
British Museum natural history collections should be governed by a board similar to present natural history committee, with one head officer (having a seat at the board), and keepers under him, 7527–7533.
Vacancies in British Museum are discussed by standing committee and heads of departments before they are filled, 7553–7558.
British Museum standing committee urged for years the propriety of retaining the collections where they are; they were outvoted by *ex officio* trustees, 7547–7570.
Natural history specimens in British Museum; objection to distributing or lending specimens; redundant specimens are exchanged, 7571–7582.

Canterbury, Archbishop of.
Archbishop of Canterbury one of the appointing trustees of the British Museum; approval of this, 7525, 7526, 7556, 7557, 7663.

Chancellor, Lord.
Lord Chancellor one of the appointing trustees of the British Museum; approval of this, 7525, 7526, 7556, 7557, 7663.

Directors, Curators, &c. in Museums. See *British Museum.*

Government.
Pressure upon Government of British Museum standing committee, for retaining the collections in their present position, and increasing the space, 7550.

Natural History Collections. See *British Museum.*

Science.
Natural science is not sufficiently represented on the board of trustees of the British Museum, 7524, 7534.
See *British Museum.*

Scientific Societies.
Objection to presidents of scientific societies being *ex officio* trustees of British Museum, 7559, 7565, 7566.

South Kensington.
Objection to removal of British Museum natural history collections to South Kensington, 7520.
See *British Museum.*

Speaker of the House of Commons.
The Speaker is one of the appointing trustees in the British Museum; approval of this, 7525, 7526, 7556, 7557, 7663.

Survey Expeditions.
Desirable that all Government Survey collections should be sent to the British Museum, 7575.

CARRUTHERS, WILLIAM, Esq., F.R.S. (Index of his Evidence.)

Banks, Sir Joseph.
Banksian herbarium at British Museum; impossibility of separating it from Banksian Library, 7739, 7740, 7759.

Carruthers, W., Esq.—cont.

Bentham, Mr.
- Opinion of Mr. Bentham in favour of retention of both Kew and British Museum herbaria; opinion modified subsequently, 7737-7740.
- Mr. Bentham's opinion, that botanical gardens are of small account to the systematic botanist, 7745.

Berlin.
- The Botanic Garden of Berlin is in close proximity to the capital, 7757, 7758.

Botany.
- An herbarium for the study of systematic botany has no connexion with a botanical garden, 7743.
- British Museum botanical collection is for the study of systematic botany, 7756.
  - See *British Museum*, *Kew*, &c.

British Museum.
- No connexion between botanical collections of British Museum and Kew; connexion unnecessary, 7715-7718.
- British Museum botanical collection wanted in London for its great population, and increasing number of scientific visitors, 7717-7722, 7734-7745.
- Keeper of British Museum botanical department can admit anyone; keeper and two assistants comprise the staff, 7723-7726.
- Botanical department of British Museum does not acquire duplicates, only sets of plants; duplicates unimportant, 7728.
- Objection to British Museum herbarium being considered inferior to that of Kew; the herbarium is unequalled in the world, 7731-7745.
- Superiority of British Museum library over that of Kew, for botanical reference, 7746-7748, 7754.
- British Museum herbarium is named quite independently of Kew; workers in botany have to consult all the great herbaria, 7749-7752.
- Specimens received into British Museum are not allowed to be sent away; approval of this rule, 7752, 7753.
- Removal of British Museum botanical collection to South Kensington will be a serious injury to science; a subsidiary library will be essential, 7755-7759.
- Botanical collection at the British Museum is for the study of systematic botany, 7756.

Brown, Mr. Robert.
- Opinion of Mr. Brown that the two herbaria, at Kew and British Museum, should be sustained, 7737.

Darwin, Mr.
- Opinion of Mr. Darwin that there should be a national botanical collection in London, 7739-40.

Directors, Curators, &c. of Museums. See *British Museum.*

Falconer, Dr.
- Dr. Falconer's opinion as to the necessity of having a botanical collection in London, 7739-40.

Geology.
- Importance to geology of retaining in London the British Museum botanical collection, 7739-40.

Henfrey, Professor.
- Opinion of Professor Henfrey as to the importance of having a botanical collection in London, 7739-40.

Hooker, Dr.
- Dr. Hooker on the different purposes of Kew and British Museum herbaria, [illegible], 7747, 7756.
- Desire of Dr. Hooker to remove the British Museum botanical collection to Kew, 7739-40.

Hooker, Sir William.
- Sir William Hooker was in favour of removing the British Museum botanical collection to Kew, 7739-40.

Kew Gardens.
- Herbaria of Kew and British Museum; clearly separated; an herbarium at Kew for garden purposes desirable, but the great scientific herbarium ought to be in London; the two herbaria are named independently, 7715-7721, 7734-7745, 7749-7752.
- Library at Kew inferior to that of British Museum, for botanical purposes, 7746-7748.
- Removal of British Museum botanical collection to Kew will be a serious injury to science, 7755-7759.
  - See *British Museum.*

Libraries.
- Superiority of British Museum library over that of Kew, for botanical purposes, 7746-7748, 7754.
- If British Museum botanical collections be removed to South Kensington, a subsidiary library will be essential, 7754, 7759.

Lindley, Dr.
- Dr. Lindley's opinion in favour of removing British Museum botanical collections to Kew, 7739-40.

Carruthers, W., Esq.—cont.

London.
- Importance of keeping the British Museum botanical collections in London, 7737-7745.

Lyell, Sir Charles.
- Sir Charles Lyell on desirability of retaining in London British Museum botanical collection, 7739-40.

Paris.
- The Botanic Garden of Paris is in the capital, 7757, 7758.

South Kensington.
- Removal of British Museum botanical collections to South Kensington will be a serious injury to science a subsidiary library will be essential, 7755-7759.
  - See *British Museum.*

Visitors to Museums. See *British Museum.*

Waterhouse, Mr.
- Illustrations by Mr. Waterhouse of the convenient locality of British Museum over Kew, 7744.

WATERHOUSE, GEORGE ROBERT, Esq. (Index of his Evidence.)

Age of Students.
- Children of 9 or 10 years would derive advantage from explanations given in British Museum, 7771-7773.

Artizans.
- Lectures given to artizans at British Museum on private days have been successful, 7771.

British Museum.
- Fossils in the British Museum; arranged differently to those in Jermyn Street; semi-zoological and semi-geological arrangement in the former, and stratigraphical arrangement in the latter, 7764-7766.
- Rock specimens in the British Museum are arranged geologically, 7764.
- Interpolating fossil collections among recent ones in British Museum would be difficult; recent specimens might be introduced among fossils, 7769-7771.
- Number of students at British Museum has greatly increased of late, 7771.
- Lectures and explanations to students, working men, &c., given in British Museum; they might be extended to school children, 7771-7773.
- Not desirable that British Museum keepers, &c. should be compelled to give lectures; they might give occasional explanations, 7774-7778.

Children.
- Desirable if school children could have explanations of specimens in British Museum, 7771-7773.

Directors, Curators, &c. of Museums. See *British Museum.*

Lectures.
- Approval of the explanations given in British Museum to students, working men, &c.; but keepers, &c. should not be compelled to lecture, 7771-7778.

Museum of Practical Geology.
- Fossils in Museum of Practical Geology are arranged stratigraphically, 7764.

Palæontology.
- Objection to interpolation of fossil with recent specimens, 7769-7771.
  - See *British Museum.*

Schools.
- Many schools visit the British Museum; explanations should be given them, 7771-7773.

South Kensington.
- In the event of removal of British Museum collections to South Kensington, the fossils should be arranged as at present, 7766.
  - See *British Museum.*

Students.
- Great increase of students in British Museum of late years, 7771.

COLE, HENRY, Esq., C.B. (Index of his Evidence.)

Admiralty.
- Greenwich Hospital Picture Gallery is governed by the Lords of the Admiralty, 9063-9066.
- Similar objects should not be exhibited by Admiralty and Patent Museum, 9136-9141.

Birmingham.
- Birmingham is inaugurating a museum of manufactures, illustrative of the trades of the district, 9148.

Cole, H., Esq.—cont.

Boards of Visitors.

Trustees of British Museum might be retained as an inspecting board, 9088–9097.

An honorary committee, for inspection of national collections, composed of noblemen, men of science and art, &c., desirable, 9090–9097.

Botanic Gardens (*Dublin*).

The Dublin Botanic Gardens are under the government of a board, 9063, 9064.

Botanic Gardens (*Edinburgh*).

The Botanic Gardens of Edinburgh are supported by parliamentary vote, 9055.

British Museum.

British Museum is supported by parliamentary vote; 103,109*l.* voted in 1870; at the rate of 3*s.* 8*d.* per visitor, 9055–9072.

British Museum trustees; they should not be abolished, but employed as a consultative body; Sloane trustees might remain; scientific trustees for natural history desirable, 9063–9066, 9088–9105.

Superfluities in British Museum should be distributed; crowded state of natural history specimens, 9073–9075, 9100–9105.

British Museum collections, when removed to South Kensington, need not be under trustees, 9094–9097.

British Museum might be better administered, at a cheaper cost, 9106–9112.

Desirability of having policemen, in lieu of ordinary attendants, at the British Museum, 9109.

Fewer visitors to British Museum every year; decline not attributable to attraction of South Kensington, 9112, 9113.

Conservatoire des Arts et Métiers.

Conservatoire des Arts et Métiers; a model for our Patent Museum; it is open on Sunday, 9099, 9132–9136.

Mining models (if Mining School be removed) might form part of a Conservatoire des Arts et Métiers, 9142.

Crystal Palace.

In 1860, in respect to total expenses of Crystal Palace, every visitor cost 1*s.* 3¼*d.*, 9067.

Dublin.

About 12,470*l.* is voted for science and art collections in Dublin, 9062.

See *Botanic Gardens* (*Dublin*), &c.

Edinburgh.

About 10,900*l.* is voted for science and art collections in Edinburgh, 9062.

Edinburgh Museum.

Edinburgh Museum is under the Lord President; it is supported by parliamentary vote; 8,474*l.* voted in 1870; costs 7*d.* per visitor, 9055–9072.

See *National Gallery* (*Edinburgh*).

Education.

Museums are instruments of education, and should be placed under a Minister of Education, 9118–9131.

Evening Exhibitions.

Large increase of visitors to Museum of Practical Geology since it has been opened in the evening, 9107.

Gladstone, Right Hon. W. E., M.P.

Approval of Mr. Gladstone's statement, as to defective management of national museums, and want of Government authority over them, 9064.

Glasnevin Botanic Gardens (*Ireland*).

Glasnevin Botanic Gardens are supported by parliamentary grant; 2,864*l.* voted in 1870; cost 3*d.* per visitor, 9055–9072.

Greenwich Hospital.

Greenwich Hospital Picture Gallery is supported by parliamentary vote; it is governed by the Lords of the Admiralty, 9055, 9063–9066.

Hampton Court.

Hampton Court Picture Galleries are supported by parliamentary vote; they are under the Office of Works, and the Lord Chamberlain, 9055, 9063–9066.

Hawes, Sir Benjamin.

In Sir Benjamin Hawes' Committee, 40 years ago, parliamentary responsibility for the British Museum was proposed, 9089.

Income and Expenditure.

Collections of science and art supported by parliamentary vote; 223,300*l.* voted for present year; about 209,400*l.* in London, 10,900*l.* in Edinburgh, and 12,470*l.* in Dublin, 9055–9062.

British Museum estimates; parliamentary vote for this year is 97,969*l.*, 9058, 9099, 9106–9112.

Cole, H., Esq.—*Income and Expenditure*—cont.

Expenses of public museums, showing cost per visitor, viz., South Kensington, 1*s.* 3*d.* per visitor, British Museum, 3*s.* 8*d.*, &c., 9067, 9072.

Payments should be made to all persons consulted for the public benefit, 9105.

Ireland. See *National Gallery* (*Ireland*), *&c.*

Jermyn Street Institution.

Royal School of Mines and Museum of Practical Geology are supported by parliamentary vote; they are under the Lord President, 9055, 9063–9066, 9072.

Large increase of visitors to Museum of Geology since it has been opened in the evening, 9107.

Royal School of Mines should retain its mining models; if removed, they might form part of a Conservatoire des Arts et Métiers, 9142.

Kew Gardens.

Kew Gardens are supported by parliamentary vote; 22,501*l.* voted in 1870; cost 9¼*d.* per visitor; under Chief Commissioner of Works, 9055–9072, 9099.

Langdale, Lord.

Opinion of Lord Langdale on parliamentary responsibility in connexion with British Museum, 9089.

London.

About 209,400*l.* is voted for science and art collections in London, 9062.

Lord President.

Royal School of Mines, Geological Museum, and Edinburgh Museum are under the Lord President, 9063–9066.

The Lord President is directly responsible to Parliament for the South Kensington Museum, 9091, 9063–9066.

British Museum, if under the Lord President, would be administered better, and more economically, 9106–9112.

Mining.

While a Mining School, library, &c. exists, mining models should remain; if removed, they might form part of a Conservatoire des Arts et Métiers, 9142.

Minister of Education.

National Museums should be under one Minister of Education, 9118–9131, 9141, 9144.

See *Parliament.*

Museum of Natural History (*Dublin*).

Dublin Natural History Museum is supported by parliamentary grant; 3,060*l.* voted last year; costs 7*d.* per visitor, 9055–9072.

Museum of Naval Architecture.

Museum of Naval Architecture and Patent Museum should not exhibit similar objects, 9136–9140.

The Naval Architecture collections (now under the Lords of the Admiralty) should be under a Minister of Education, 9141.

Museum of Practical Geology. See *Jermyn Street Institution.*

Museums.

Enumeration of museums supported by parliamentary vote, and working expenses, calculated per visitor, 9055–9062, 9067, 9072.

Difficult to determine in museums what is science and what is art, 9056, 9057.

For proper government of national museums a Minister of Education is essential, 9063–9148.

Approval of turnstiles in museums for counting number of visitors, 9067–9070.

Evil arising from similar objects being under different managements in museums, 9073.

Local museums are in want of specimens, while British Museum is overloaded; specimens should be sent out on loan, 9073–9078.

Natural tendency of all museums to become crowded and dirty, 9075.

Increasing demand on South Kensington from local museums for loan of specimens, 9076.

Last year more than 800,000 persons inspected the specimens in local museums lent by South Kensington, 9076.

Scientific collections for museums are less adapted for circulation than objects of art, 9078.

An honorary inspecting board for the national collections desirable; it should comprise persons of rank, and men noted in science and art, 9090.

Estimates of British Museum, South Kensington Museum, &c., are prepared under Treasury authority, 9098, 9099.

Desirability of employing policemen as attendants in museums, 9109.

Cole, H., Esq.—*Museums*—cont.

Public money should be spent on provincial museums, 9148.

A museum of manufactures is being inaugurated by Birmingham, 9148.

National Gallery (London).

National Gallery is supported by parliamentary vote; vote for 1870, 16,566*l.*; costs 4½*d.* per visitor; it is governed by trustees, 9055–9072, 9099.

Half the National Gallery pictures could be circulated about the country with advantage, 9074, 9083.

National Gallery (Edinburgh).

Edinburgh National Gallery is supported by parliamentary vote; it is under the board of manufactures, 9055, 9063–9066.

National Gallery (Ireland).

National Gallery in Dublin is supported by parliamentary vote; it is under trustees and a board; 2,393*l.* voted in 1870, 9055–9072, 9063–9066.

National Portrait Gallery (London).

National Portrait Gallery is supported by parliamentary vote; 2,253*l.* voted in 1870; costs 9*d.* per visitor; it is governed by trustees, 9055–9072, 9145.

Increase of visitors to National Portrait Gallery since its removal to South Kensington, 9145–9147.

Natural History Museum (Ireland).

The Dublin Natural History Museum is under a board, 9063–9066.

Parliament.

Number and working expenses of museums supported by parliamentary vote, 9055–9062, 9067, 9072.

The Lord President is responsible to Parliament for South Kensington Museum, 9063–9066, 9091.

Evils arising from want of direct parliamentary authority over national museums, 9063–9148.

National museums and collections should be under a Minister of Education, responsible to Parliament, 9088, 9118–9131.

Patent Office Museum.

Museum of Patents is under Commissioners of Patents; it is supported by parliamentary vote, 9063–9066, 9099.

Disapproval of management of Patent Office; model for Patent Museum would be Paris Conservatoire des Arts et Métiers, 9099, 9132–9135.

Unnecessary to have similar objects exhibited by Patent Museum and Admiralty, as at South Kensington, 9136–9141.

President of the Committee of Council. See *Lord President.*

Royal Dublin Society.

Royal Dublin Society has a parliamentary grant; it is under a board, 9055, 9063–9066.

Royal Hibernian Academy.

Royal Hibernian Academy has a parliamentary grant; it is under a board of academicians, 9055, 9063–9066.

Royal Irish Academy.

The Royal Irish Academy is supported by parliamentary vote; it is under a board, 9055–9066.

Royal School of Mines. See *Jermyn Street Institution.*

Science.

Difficulty of determining in museums what is science and what is art, 9056, 9057.

Sheepshanks, Mr.

Mr Sheepshanks' pictures; they were presented as a nucleus of a collection of British art; the nation has not kept faith, 9073, 9084.

Sloane Collection. See *British Museum.*

South Kensington Museum.

South Kensington Museum is supported by parliamentary vote; in 1870, 63,864*l.* was voted; cost per visitor, 1*s.* 3*d.*; it is under the Lord President, 9055–9072, 9091.

Circulation of specimens by South Kensington Museum; increasing demand, 9076–9084, 9111–9118, 9148.

Liberality of owners of pictures, &c. in lending them to South Kensington, 9086.

Commission of noblemen and others formed occasionally at South Kensington, to promote making of collections; success of system, 9090–9097.

At South Kensington there are no trustees; not wanted; professional advisers are consulted, and paid for advice, 9092–9097, 9104.

Attraction of South Kensington not the cause of decline of British Museum, 9113.

Great increase of visitors to National Portrait Gallery since its removal to South Kensington, 9145–9147.

Cole, H., Esq.—cont.

Sundays.

The Conservatoire des Arts et Métiers, Paris, is open free on Sundays, and is crowded, 9099.

Tower of London.

Tower of London collections are supported by parliamentary vote, 9055.

Trustees. See *British Museum, &c.*

Visitors to Museums.

Expenses of various national museums of science and art, showing cost per visitor, 9067, 9072.

Visitors to local museums exhibiting objects lent by South Kensington; 800,000 last year; since 1854, 3,073,096, 9076.

Conservatoire des Arts et Métiers is open free on Sundays and Thursdays, and is crowded, 9099.

Large increase of visitors to Museum of Practical Geology since it has been opened in the evening, 9107.

Visitors to British Museum decline in number every year, 9112.

Great increase of visitors to National Portrait Gallery since its removal to South Kensington, 9145–9147.

Zoological Society (Dublin).

The Dublin Zoological Society has a parliamentary grant; it is under a board of the Royal Dublin Society, 9055, 9063–9066.

GUNTHER, ALBERT, Esq. (Index of his Evidence.)

Accommodation for Science Purposes.

Most university museums in Germany are provided with students' rooms or laboratories, 10,114.

British Museum should have accommodation for students to dissect; small space only allotted for this in new building, 10,118, 10,124, 10,125.

Artizans.

Lectures to artizans should be given at the British Museum, 10,119–10,123.

Assistant Professors.

Advantage of the German method of selecting students as assistants to professors, 10,099.

Berlin. See *Germany.*

Botany.

In all German universities the Hortus Siccus is joined to the botanical garden, 10,097, 10,098.

Botanical specimens can be obtained in much larger numbers than zoological, 10,164.

British Museum.

British Museum keepers, &c. should lecture on their specimens, 10,115–10,127.

Accommodation for dissecting, &c., should be provided in British Museum, 10,118, 10,124, 10,125.

When British Museum collections are removed, a library will be a necessity; Banksian library insufficient, 10,128, 10,190–10,194.

British Museum is far in advance of all other museums with regard to catalogues, 10,135.

Survey expeditions have furnished but little to British Museum, 10,144–10,147.

Zoological duplicates in British Museum; few, and properly applied; could not be furnished to provincial museums, 10,159–10,173.

On account of danger from fire, British Museum wet specimens should be kept separate, 10,195–10,201.

Catalogues of Scientific Collections.

Superiority of British Museum in respect to catalogues, 10,132–10,135.

Duplicate Specimens. See *British Museum.*

France.

Muséum d'Histoire Naturelle, Paris; successfully utilized for instruction; lectures free; governed by a director, responsible to a minister, 10,136–10,139, 10,185–10,189.

Germany.

German museums; numerous and important; aided by the State; all well arranged, 10,083–10,114, 10,130–10,135, 10,171–10,178.

Berlin Museum; important collection; departments controlled by professors, subject to minister; income small, 10,094–10,103, 10,179–10,184.

Government.

Government aid to museums in Germany, 10,083–10,114.

State aid should be given to museums raised by private contributions, 10,173.

GÜNTHER, A., Esq.—cont.

Grants for Science Purposes.
- Local contributions for museums should be aided by Government grants, 10,173.

Holland.
- Leyden Museum; rich collection of birds, &c., 10,140–10,142.
- Exertions made by Dutch Government to have natural history specimens sent from their colonies, 10,143.

Laboratories.
- Laboratories are attached to most university museums in Germany, 10,114.

Lectures.
- In German universities, lectures are given in immediate connexion with the museums, 10,111–10,114.
- Lectures on British Museum collection should be given by keepers, &c., 10,115–10,127.
- At the Muséum d'Histoire Naturelle, Paris, heads of departments give free lectures, 10,136–10,139, 10,187.

Leyden Museum. See *Holland.*

Libraries.
- If British Museum collections be removed, a library will be essential; Banksian Library alone not sufficient, 10,128, 10,190–10,194.
- A tolerable natural science library could not be formed under 25 years, 10,190.

Minister of Instruction.
- In Germany and France museums are subject to a minister; he should have high scientific qualifications, 10,099–10,101, 10,111–10,114, 10,179–10,184.

Muséum d'Histoire Naturelle (Paris). See *France.*

Museums.
- Continental museums are mostly deficient in catalogues, 10,135.
- Educational importance of provincial museums they might be under inspectors; they should be aided by the State, 10,144–10,173.
  - See *British Museum, France, Germany, &c.*

Natural History Collections.
- Natural history collections in Germany; importance of the Berlin collection, 10,083–10,114.
- Muséum d'Histoire Naturelle collections; lectures upon them, 10,136–10,139.
- Rich natural history collection in Leyden; encouragement to collection of specimens given by Dutch Government, 10,140–10,143.
- Palæontological and recent zoological specimens should be united, and under one director, 10,195 10,201.
- Danger from fire of wet natural history specimens, 10,195–10,201.
  - See *British Museum.*

Palæontology.
- Palæontological collections of British Museum should be united with recent specimens, and be under one head, 10,195–10,201.

Professors.
- German and French professors control museums, subject to minister; they lecture on the collections, 10,099–10,101, 10,111–10,114, 10,136–10,139, 10,179–10,189.

Schools.
- Scientific collections in German schools are insignificant; pupils are taken to public museums, 10,088–10,091.
- Usefulness of local museums for instruction of pupils in schools, 10,150.

Scientific Societies.
- In Germany, museums have induced the formation of many important natural history societies, 10,086.

Students.
- Selection of German students to act as assistants to professors; advantage of the system, 10,099.
- At British Museum, students should be able to have both wet and dried specimens in their working rooms, 10,195–10,201.

Survey Expeditions.
- German survey expeditions; zoological result not great, 10,104–10,107.
- Survey expeditions have but little profited British Museum, 10,144–10,147.

Universities.
- Importance of museums in universities of Germany, 10,083, 10,084, 10,093, 10,099–10,101, 10,111–10,114.
- In German universities the Hortus Siccus is joined with the botanical garden, 10,097, 10,098.

THOMSON, C. WYVILLE, Esq., LL.D., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
- Bad accommodation for natural history department at Edinburgh University; new building expected, 10,203–10,206.

Belfast.
- Local natural history society and museum at Belfast; good collection also in Queen's College, 10,309.

Council of Scientific Advice.
- For Museums of Science and Art Department there should be a scientific council for reference, 10,222, 10,299.

Denmark.
- Connexion of natural history collections with schools in Denmark, 10,304.

Edinburgh Museum. See *Museum of Science and Art (Edinburgh).*

Edinburgh University.
- Promotion of science at Edinburgh University, 10,202–10,310.
  - See *Professors, Students, &c.*

Evening Exhibitions.
- Edinburgh Museum of Science and Art is lighted in the evening, and attracts large numbers, 10,290–10,298.

Germany.
- Local collections of natural history are connected with superior schools in Germany, 10,304.

Laboratories.
- Zoological laboratory instruction to be given at Edinburgh University, 10,203–10,205.

Lectures.
- Lectures on recent and fossil zoology given at Edinburgh University; practical instruction to be given, 10,203–10,205.

Liverpool Free Museum.
- Liverpool Free Museum is equally useful for university and popular instruction; it is very successful, 10,225, 10,226, 10,295–10,297.

Museum of Science and Art (Edinburgh).
- Edinburgh Science and Art Museum; its transference from Edinburgh University to Science and Art Department; objection to existing arrangement; natural history portion should be subject to Regius Professor, 10,207–10,289.
- Natural history collections of Edinburgh Science and Art Museum are much visited; lectures on them are delivered, 10,290–10,298.
- Science and Art Museum of Edinburgh should be especially suited to teachers; and it might provide nuclei for local collections, 10,302.

Museums.
- Foundation of Stephen's Green and Jermyn Street Museums led to that of Edinburgh Museum, 10,213.
- Local museums should be places both of recreation and of instruction, 10,300–10,309.
  - See *Liverpool Free Museum, &c.*

Natural History.
- Instruction in recent and fossil zoology at Edinburgh University; bad accommodation for teaching, 10,203–10,206.
- Natural history collections in Edinburgh Museum of Science and Art; they should be controlled by Regius Professor; they are much visited; lectures on them are given, 10,207–10,289.
- Collections of natural history specimens should be available for all superior schools, as in Germany, &c., 10,304 10,307.

Practical Instruction.
- Practical laboratory instruction to be given to zoological class at Edinburgh University, 10,203–10,206.

Professors.
- Regius Professor of Natural History at Edinburgh University; he lectures on recent and fossil zoology, and gives practical instruction, 10,202–10,205.
- Position of Regius Professor with regard to Science and Art Museum; he should have control over the natural history portion, 10,207–10,289.

Schools.
- Natural history collections should be available for schools, as in Sweden, &c., 10,304–10,307.

Science.
- Promotion of science at Edinburgh University, 10,202–10,310.

THOMSON, Prof.—cont.

Science and Art Department.
Transference to Science and Art Department of Edinburgh University Museum; objection to this arrangement, 10,207–10,289.
Science and Art Department looks more to attraction than to scientific teaching of museums, 10,209.

Scientific Societies.
Belfast local natural history society, and useful museums, lately instituted, 10,306–10,308.

Sweden.
Swedish schools have natural history collections connected with them, 10,304.

REEKS, TRENHAM, ESQ. (Index of his Evidence.)

Evening Exhibitions.
Museum of Practical Geology open two evenings a week; great cost for gas, &c. 13,819–13,831.
Minerals and fossils cannot be properly inspected by gaslight, 13,829.

Geology.
Museum of Practical Geology founded to illustrate industrial applications of geology, 13,818.

Income and Expenditure.
Museum of Practical Geology costs 4,054*l.* annually; of 500*l.* spent in gas, 400*l.* might be saved, 13,818–13,831.

Libraries.
Valuable scientific library in Museum of Practical Geology, 13,818.

Museum of Practical Geology.
Museum of Practical Geology, founded to exhibit industrial applications of geology, 13,816 13,831.
Evening exhibition of Museum of Practical Geology involves useless cost, and damage to specimens, 13,819–13,831.

Natural History Specimens.
Minerals and fossils cannot be properly studied by gaslight, 13,829.

Visitors to Museums.
There are about 6,600 evening visitors per annum at Museum of Practical Geology, they mostly come from idle curiosity, 13,823.

DONNELLY, MAJOR, J. F. D., R.E. (Index of his Evidence.)

Accommodation for Science Purposes.
Accommodation wanted for Educational Department at South Kensington Museum, 13,833, 13,839.
The Patent and other models at South Kensington might be housed in the southern arcades of the Horticultural Gardens, 13,847.

DONNELLY, Major—cont.

Apparatus for Science Purposes.
Scientific apparatus at South Kensington Museum, mostly presented by makers, 13,833–13,838.

Bethnal Green Museum.
Food and Animal Products' Collections from South Kensington are now at Bethnal Green, 13,842, 13,843.

Conservatoire des Arts et Métiers.
Patent and other models at South Kensington should form one museum like the Conservatoire des Arts et Métiers, 13,846–13,851.

Dublin.
Cost of museums, &c., in Dublin, 13,859.

Edinburgh.
Expense of museums, &c., in Edinburgh, 13,859.

Education.
Valuable Educational Library and Museum in South Kensington Museum, 13,833.

Income and Expenditure.
Cost of museums, libraries, &c., in Dublin and Edinburgh for 1873–4, 13,859.

Libraries.
Educational library in South Kensington Museum contains 30,000 books and pamphlets, 13,833.

Mechanics.
The Patent, naval, and other models at South Kensington should form a museum for illustration of applied mechanics, 13,845–13,851, 13,856, 13,857.

Patent Museum.
The Patent, naval, and other models at South Kensington should form one museum of mechanical arts, 13,845–13,851, 13,856, 13,857.
Objection to a museum specially for patents, 13,848.
Models in Patent Museum should not be admitted as patents, but as illustrations of applied mechanics, 13,857.

Philosophical Instrument Makers.
Philosophical instruments at South Kensington Museum are mostly presented by the makers, 13,834.

Schools.
Apparatus for elementary teaching exhibited at South Kensington Museum, and sent out to schools, 13,833–13,838.

Science and Art (Ireland) Commission.
No action taken upon Report of Science and Art (Ireland) Commission, 13,858.

South Kensington Museum.
South Kensington Museum, and its collections bearing on science, 13,833–13,857.

Visitors to Museums.
Visitors to South Kensington Educational Department comprise clergymen, school-managers, teachers, &c., 13,833.

ANALYSES OF EVIDENCE

RESPECTING THE

UNIVERSITIES OF LONDON AND DURHAM.

University of London.

RPENTER, WILLIAM BENJAMIN, Esq., M.D., F.R.S. (Index of his Evidence.)

Age of Students.
- London University candidates for matriculation are between 16 and 18 years of age; the best come from good schools, 7867.
- Science can be well taught to students of 16 to 17 years of age, 7869.

Botany.
- Ignorance of botany shown by Indian Civil Service and London University Medical examinations, 7873–7878.

Cambridge University.
- Colleges at Cambridge might stimulate original research in awarding fellowships, 7897, 7898.
- Rewards for science at Cambridge have had a beneficial effect; keen competition, 7899–7902.

Chemistry.
- Chemistry is one subject best suited for beginning scientific study, 7878.
- Advantage of chemistry with respect to mental training, 7897.

Civil Service Commission. See *Indian Civil Service.*

Degrees.
- For London University B.Sc. degree, the best candidates are those who have studied under professors, 7870–7872.
- Men who have taken London University B.A. degree can take B.Sc. degree on passing in additional subjects; they mostly fail, 7871, 7872.
- Mathematics, logic, moral philosophy, and mechanical philosophy, are common to B.A. and B.Sc. degrees of London University, 7871.
- Evidence of original research might be made a requisite in London University D.Sc. examinations, but not at present, 7882, 7883, 7888.
- In second examination for London University B.Sc. degree, practical knowledge should be required, 7885–7887.
- London University science degrees established seven or eight years; four D.Sc. degrees taken last year; 15 B.Sc. degrees taken annually, 7889–7893.

Examinations.
- London University matriculation examination shows that the best students have attended courses, not worked from text-books, 7865, 7866, 7870–7872.
- Candidates at London University matriculation examination are mostly 16 to 18 years of age, 7867.
- The London University matriculation examination should test a complete school education, 7867.
- Indian Civil Service examinations in botany and zoology show badly prepared candidates; subjects got up merely by reading, 7873–7877.
- Large number of failures in botany in London University medical examinations, 7878.
- London University examinations show little advance of scientific teaching in schools, 7878, 7879.
  - See *Degrees.*

Fellowships and Scholarships.
- Fair distribution of fellowships for science should be made by universities, 7881, 7882, 7897.
- In awarding fellowships by universities, evidence of original research has not been required, 7898.
- Fellowships, &c. for science awarded of late by Oxford and Cambridge have had a beneficial effect, 7899–7902.

CARPENTER, Dr.—cont.

Indian Civil Service.
- Want of preparation in botany and zoology shown by candidates for Indian Civil Service, 7873–7877.

Laboratories.
- Laboratory work is required for the scientific medical, but not for B.Sc., examination, at London University; it should be required for B.Sc. degree, 7887.

Literature.
- Dull literary students improved by study of chemistry, 7897.

London University.
- Promotion of science by London University, 7865–7896.
  - See *Degrees, Students, &c.*

Mathematics.
- Teaching of natural philosophy solely from mathematical side is objectionable, 7895.

Medicine.
- Failures in botany in London University scientific medical examinations, 7878.
- Laboratory work is required in London University scientific medical examination, 7887.

Natural Philosophy.
- Natural philosophy is one subject best adapted for beginning scientific training, 7878.
- Objection to natural philosophy being taught solely from the mathematical side, 7895.

Original Research.
- Want of encouragement to science in universities militates against pursuit of original research, 7881.
- A dissertation involving research might ultimately (but not at present) be made indispensable to London University D.Sc. degree, 7882, 7883, 7888.
- Fellowships for science given by Oxford and Cambridge would stimulate research, if research were recognised in award of fellowships, 7897, 7898.

Oxford University.
- Colleges at Oxford might greatly stimulate original research in awarding fellowships, 7897.
- Rewards for science at Oxford University have had a most beneficial effect, 7899.

Practical Instruction.
- Practical knowledge should be shown in second examination for London University B.Sc. degree, 7885–7887.

Saint John's College (Cambridge).
- Science exhibition at St. John's College; 12 candidates, 7901, 7902.

Scholarships. See *Fellowships and Scholarships.*

Schools.
- For London University matriculation examination, candidates from certain schools come up well prepared, 7866–7868.
- London University matriculation examination should test a complete school education, 7867.
- Scientific instruction can be well given in schools to students of 16 to 17 years of age, 7867–7869, 7878.
- London University examinations show little advance in scientific teaching in schools, 7878, 7879.
- If science be introduced into endowed schools, private schools will follow the example; influence of universities will be felt in schools, 7894.
- Elementary scientific instruction in schools might be given by men not solely teachers of science, 7895, 7896.

CARPENTER, Dr.—cont.

Science.
Importance of scientific teaching in schools, as a matter of mental training, 7869, 7878.
Natural philosophy and chemistry are the subjects best suited to begin scientific training, 7878.
Scientific teaching in endowed schools will be followed in private schools, 7894–7896.
Importance of connecting together the different departments of scientific teaching, 7895.
Instance of dull students in literature being improved by study of chemistry, 7897.

Students.
In London University matriculation examination, students who come from good schools mostly succeed, 7865–7869.
Scientific instruction can be well given to students of 16 to 17 years of age, 7867–7869.
Successful students at London University shown to have worked under professors, not from text-books, or private study, 7870–7872.
Candidates for London University degrees, 7870–7893.
Imperfect preparation in botany and zoology shown by candidates for Indian Civil Service, 7873–7877.
Failure of students in botany in London University medical examinations, 7878.

CARPENTER, Dr.—*Students*—cont.
In London University scientific medical examination candidates are obliged to do laboratory work, 7887.
Instances of dull classical students being improved by study of chemistry, 7897.
See *Degrees.*

Teachers.
In schools, elementary scientific instruction could be given by general teachers, 7895, 7896.

Text-books.
Evil of preparing solely from text-books, as shown in failures at London University examinations, 7865–7869.

Trinity College (Cambridge).
Scholarships for science at Trinity College; limited to members of university; keen competition; seven candidates, 7900, 7901.

Universities.
Want of encouragement to science in universities militates against original research, 7881.
Fair distribution of university rewards should be made; good effect of those already given, 7881, 7882, 7897–7894.

Zoology.
Ignorance of zoology shown by Indian Civil Service candidates, 7873–7877.

University of Durham.

LAKE, THE VERY REV. WILLIAM CHARLES, D.D.
(Index of his Evidence.)

Accommodation for Science Purposes.
Good rooms in Wood Memorial Hall to be used for Newcastle College of Physical Science, 8759, 8819.

Age of Science Students.
Students of 16 or 17 years of age may be expected at Newcastle College of Science, 8764.

Apparatus for Science Purposes.
Scientific apparatus is furnished to Newcastle College of Science by various philosophical societies, &c., 8760.

Assistant Professors, Demonstrators, and Teachers.
Two skilled assistants to professors are to be appointed at Newcastle College of Science, 8761.

Bell, Mr. Lowthian.
Mr. Lowthian Bell on advantage of a school of science, and Newcastle as a locality, 8757, 8795–8798, 8812, 8813.

Biology.
Professorship of biology desirable at Newcastle College of Science; funds insufficient for this, 8789–8792, 8838.
Objection to combining professorship of biology with that of geology and mineralogy, 8790.

Boarding-houses for Students.
Boarding-houses for students are not contemplated at present for Newcastle College of Science, 8820, 8821.
Failure of boarding-house in connexion with Newcastle Medical School, 8821.

Chemistry.
Professorship of chemistry at Newcastle College of Science, 8766.
Chemical laboratory in building belonging to the Medical Wood School at Newcastle, 8823.

Durham.
Divided opinion respecting desirability of founding a school of science at Durham; opinion of Mr. Nicholas Wood in favour of it, 8757, 8762, 8793–8804.
Employers of labour in Durham are now to a great extent favourable to the Newcastle College of Science, 8762, 8793–8804.

Durham University.
Durham University and its connexion with Newcastle College of Science, 8757–8788.
See *Lectures, Students, &c.*

LAKE, Rev. Dr.—cont.

Education.
General education, with especial reference to physical science, should be given at Newcastle College of Science, 8774, 8775.

Engineering.
Young men wishing to become mining engineers will be attracted to Newcastle College of Science, 8764.
Failure of engineering course at Durham University; the students lived at a distance, 8777, 8778.
Education of viewers has been almost exclusively in engineers' offices, 8824.
Difficulties of students articled to engineers in respect to their attendance on scientific courses of lectures, 8829, 8830.

Examinations.
At Newcastle College of Science, preliminary examination will probably be necessary, 8764.
Durham University examinations in physical science; to be conducted by distinguished men; to be held at Newcastle; distinctions to be awarded, 8780–8782.
Newcastle Medical School examinations are conducted under authority of Durham University, 8783, 8784.

Experimental Philosophy.
Professorship of experimental philosophy at Newcastle College of Science, 8766.

Geology.
Professorship of mineralogy and geology at Newcastle College of Science, 8766.
Combination of professorship of biology with that of geology and mineralogy not desirable, 8790.

Government.
Government aid to be solicited for Newcastle College of Science; it may fairly be claimed, 8773, 8774, 8805.

Income and Expenditure.
1,000*l.* a year offered by Durham University to Newcastle College of Science; 60,000*l.* barely sufficient to start the college; 2,000*l.* to be devoted to professors, secretary, &c.; Government aid to be asked for, 8757–8776, 8805.
Two thirds of fees to be given to professors at Newcastle College of Science, 8769.

Laboratories.
There is a chemical laboratory at Newcastle Medical School, 8823.

Lectures.
At Durham University, lectures might from time to time be given by the Newcastle scientific professors, 8763.

Lake, Very Rev. Dr.—cont.

- Lectures at Newcastle College of Science; teaching is of an advanced description, 8766–8772.
- Lectures on physical science, and examinations, at Durham University; failure of engineering lectures, 8777–8782.
- Difficulty of engineering articled students attending scientific lectures, 8829, 8830.

Leeds.
- A scientific college, founded at Leeds, should be affiliated to Durham University, 8785–8788.

London.
- Mining schools desirable both at London and Newcastle, but for different purposes, 8805–8811.
- London a less favourable locality than Newcastle in which to give practical instruction to a large body of men, 8805–8811.

Mathematics.
- Professorship of pure and applied science at Newcastle College of Science; instruction to be advanced, 8766–8768.

Medicine. See *Newcastle Medical School.*

Mineralogy.
- Professorship of mineralogy and geology at Newcastle College of Science, 8766.
- Professorship of biology should not be combined with that of mineralogy and geology, 8790.

Mining.
- Students working for high posts in the mining profession may be expected at Newcastle College of Science, 8764.
- Mining schools, with different purposes, desirable, both at London and Newcastle, 8805–8811.
- Newcastle College of Science is to have the character of a mining school; but no special desire has been expressed for a professorship of mining, 8835–8840.

Newcastle.
- Division of opinion as to desirability of founding a college of science at Newcastle, 8757, 8762.
- Durham University scientific examinations are to be held at Newcastle, on account of laboratories, 8780–8782.
- Newcastle a better place than London for practical scientific teaching of a large body of men, 8805–8811, 8803, 8804.
- Surrounding industries, and vicinity of Durham University, were the causes of establishing the College of Science at Newcastle, 8812.

Newcastle College of Physical Science.
- Foundation, &c. of Newcastle College of Science, 8757–8841.
  - See *Professors, Students, &c.*

Newcastle Medical School.
- Examinations at Newcastle Medical School are conducted under authority of Durham University, 8783, 8784.
- Assistance expected by Newcastle College of Science from the Medical School at Newcastle, 8792.
- Newcastle Medical School not considered the only medical school connected with Durham University, 8788.
- Failure of boarding-house in connexion with Newcastle Medical School, 8821.
- There is a chemical laboratory at Newcastle Medical School, 8823.

Northumberland.
- Employers of labour in Northumberland favourable to Newcastle College of Science, 8757, 8762.

Northumberland, Duke of.
- Offer of funds, by late Duke of Northumberland, to found a college of science at Durham, 8762, 8793.

Owens' College.
- Newcastle College of Science should ultimately become like Owens' College, 8769, 8774.

Practical Instruction.
- For practically instructing a large body of men, Newcastle a better place than London, 8805–8811.

Professors.
- Newcastle College of Science is to have four professors; they will have two thirds of the fees, 8761, 8769.
- Professors living at Durham could not lecture in Newcastle College of Science, 8763.
- The small amount of scientific instruction required at Durham University can be given by professors at Newcastle, 8763.

Lake, Very Rev. Dr.—cont.

Professorships.
- Newcastle College of Science will have four professorships, viz., mathematics, chemistry, experimental philosophy, and mineralogy and geology, 8766, 8768.
- Professorships in English, French, and German should be added to Newcastle College of Science, 8774, 8775.
- Professorship of biology desirable at Newcastle College of Science; funds insufficient, 8789–8792, 8838.
- Professorships of mining, civil engineering, and chemical technology not contemplated at present at Newcastle College of Science, 8817, 8818, 8835–8840.
- Desirable to establish at Newcastle just those professorships valuable to the great works of the north, 8840.

Religion.
- No religious test to be imposed at Newcastle College of Science, 8822.

Royal School of Mines.
- Education given at the Royal School of Mines but little influences education in the north, 8805–8811.

Science.
- Establishment of the Newcastle College of Science, 8757–8841.
- Majority of employers in the north appreciate scientific instruction, 8795–8804.

Students.
- Varieties of students, especially mining engineers, expected at Newcastle College of Science, 8764.
- Preliminary examination will probably be necessary for students at Newcastle College of Science, 8764.
- Newcastle College of Science students expected to come prepared in mathematics, &c., 8767, 8768.
- Scientific instruction and examinations for Durham University students, 8769–8782.
- No religious test to be imposed on students at Newcastle College of Science, 8822.
- Students articled to engineers have difficulty in attending scientific courses, 8829, 8830.

Wood, Mr. Nicholas.
- Evidence of Mr. Nicholas Wood in favour of a school of science, and Durham as a locality, 8757, 8795–8798.

BELL, ISAAC LOWTHIAN, Esq. (Index of his Evidence.)

Accommodation for Science Purposes.
- Good lecture rooms provided for Newcastle College of Physical Science; it should have a building of its own; the laboratory arrangements deficient, 9193, 9194.

Artizans.
- Artizans likely to devise improvements in mechanical, not in chemical, operations, 9169, 9170.

Belgium.
- In Belgium, where practical science is required, scientific men and science schools are to be found, 9158.

Biology.
- A chair of biology will be desirable for Newcastle College of Science, 9153, 9195.

Chemistry.
- Chemistry is one subject of instruction at Newcastle College of Science, 9153, 9155.
- Apprenticeship in chemical works should be preceded by scientific instruction, 9178–9182.
- Chemical laboratory arrangements in Newcastle College of Science are deficient, 9193, 9194.

Continent.
- On the continent there are many eminent scientific men devoted to questions of applied science, 9157, 9158.

Durham University.
- Durham University originated the movement for founding Newcastle College of Science; advantage of affiliation, 9151, 9198, 9199.
- Durham University elects two professors at Newcastle College of Science, and gives 1,000*l.* a year, 9200–9202.

Engineering.
- A chair of civil and mechanical engineering will be desirable at Newcastle College of Science, 9153, 9154.
- Apprenticeship in engineering works should be preceded by scientific instruction, 9178–9191.
- Objection to college workshops for engineering students, 9186–9191.

Bell, I. L., Esq.—cont.

England.
Instruction in metallurgical science much wanted in England; more common on the continent, 9155–9158.

France.
Where practical science is required, in France, scientific men and science schools are to be found, 9158.

Geology.
Geology is one subject of instruction at Newcastle College of Science, 9153.

Germany.
In Germany, scientific men and science schools are found where practical science is required, 9158.

Government.
Government should aid local effort in respect to Newcastle College of Science, &c., 9156–9161, 9196, 9199, 9201.

Income and Expenditure.
30,000*l.* required for Newcastle College of Science is nearly raised; 1,000*l.* a year contributed by Durham University; Government aid desirable, 9150, 9151, 9156–9161, 9199–9202.

Laboratories.
Laboratory arrangements in Newcastle College of Science are deficient, 9193, 9194.

London.
London is not the best place for teaching science in its applications, 9157, 9158.

Manufactures.
Men seeking to become managers of manufactories will probably enter Newcastle College of Science, 9164, 9165.
Most of the great improvements in iron manufacture have emanated from England, 9166–9177.
Scientific men devoted to research, &c. should be placed in manufacturing centres, 9174–9177.
Apprenticeship in chemical manufactories, &c. should be preceded by scientific instruction, 9178–9182.

Mathematics.
Mathematics, pure and applied, is one subject of instruction at Newcastle College of Science, 9153.

Metallurgy.
Instruction in metallurgical science is much wanted in this country, 9155–9158.
Enumeration of distinguished foreigners devoted to practical operations of metallurgy, 9157.
Important English inventions in manufacture of iron, &c., 9166–9177.
Apprenticeship in metallurgical works should be preceded by scientific instruction, 9178–9182.

Mineralogy.
Mineralogy is one subject of instruction at Newcastle College of Science, 9153.

Mining.
A chair of mining will become desirable at Newcastle College of Science, 9153, 9154.

Navigation.
For navigation, a chair may become desirable at Newcastle College of Science, 9154.

Newcastle College of Physical Science.
Foundation, &c. of Newcastle College of Physical Science, 9161–9197.
See *Professors, Students, &c.*

Original Research.
Scientific men, devoted to original research, should be placed in industrial centres, 9174–9177.

Physics.
Physics is one subject of instruction at Newcastle College of Science, 9153.

Practical Instruction.
Engineers, chemists, &c. should not have practical workshop instruction simultaneously with theoretical teaching, 9178–9187.
Objection to college workshops for practical instruction, 9186–9191.

Professorships.
Four professorships provided for Newcastle College of Science; professorship of biology, in addition, desirable, 9195.

Royal School of Mines.
Royal School of Mines affords the means of acquiring a sound scientific education, 9157, 9162, 9163.

Bell, I. L., Esq.—cont.

Science.
Necessity of scientific education for conduct of large industries, 9152.
Mathematics, chemistry, geology, mineralogy, and physics are subjects of instruction in Newcastle College of Science; biology, mining, navigation, &c. may ultimately be added, 9153–9155.
Instruction in metallurgical science is much wanted in this country; it is more common abroad, 9155–9158.
Science colleges should be aided by Government, 9156–9161.
In industrial centres, there should be scientific men to explain the surrounding phenomena, 9157, 9158, 9174–9177.
On the continent there are scientific schools in places where practical science is required, 9157, 9158.
Most of the great improvements in iron manufacture have emanated from England, 9166–9177.
Theoretical science formerly disregarded by manufacturers; more just appreciation now, 9171–9177.
Scientific instruction of apprentices to engineers, &c. has been neglected; simultaneous college and workshop instruction not desirable for them, 9178–9191.

Students.
Men seeking to become managers of manufactories, &c. would probably enter Newcastle College of Science, 9164, 9165.
Students of applied science should not have simultaneous practical instruction; science should be learned before apprenticeship, 9178–9191.
Objection to college workshops for students, 9186–9191.

Sweden.
In Sweden, where practical science is required, scientific men and science schools are to be found, 9158.

Workshops in Colleges.
Objection to establishment of workshops in connexion with colleges, 9186–9191.

ARMSTRONG, Sir WILLIAM G. (Index of his Evidence.)

Accommodation for Science Purposes.
Present accommodation for Newcastle College of Physical Science is a makeshift; separate buildings will be essential, 9216.

Age of Students.
Students destined for business should acquire their education before 16 or 17 years of age, 9242.

Agriculture.
Great want of scientific knowledge among persons engaged in agriculture, 9204, 9255, 9260, 9261.
Agriculturists have in some degree encouraged the Newcastle College of Science, 9260.

Chemistry.
Want of scientific knowledge among persons engaged in chemical manufactures, 9204–9206.

Continent.
Local scientific colleges are more common on the continent than in England, 9236.

Education.
Defective education in science of persons engaged in manufactures, agriculture, &c., 9204–9206.

Elswick.
At Elswick, there are evening science classes, largely attended; students are selected for appointments, 9229–9235.

Engineering.
Great want of scientific knowledge among persons engaged in engineering, 9205.

England.
Local scientific colleges are more common on the continent than in England, 9236.

Evening Classes.
Evening instruction at Newcastle College of Science desirable for foremen, apprentices, artificers, &c., 9208, 9229–9235.
Evening science classes at Elswick largely attended, 9229–9235.

Government.
Newcastle College of Science has a sound claim to Government aid, 9212–9216, 9250, 9253.

Armstrong, Sir W. G.—cont.

Income and Expenditure.
Government aid should be given to the funds of Newcastle College of Science, 9212–9216, 9250, 9253.
Liberal contributions made by employers of labour to Newcastle College of Science, 9217.
With larger funds, Newcastle College of Science could be more efficient; annual income will be mainly expended on professors, 9250, 9251.

Leeds.
A science college at Leeds desirable, 9259.

London.
London is too distant from manufacturing centres for a science college, 9218–9221.

Manufactures.
Want of scientific knowledge among persons engaged in manufactures, 9204–9206, 9255, 9257–9260.
Apprentices in manufactories commence at about 16 years of age; foremen appointed at 21; latter usually advance to higher appointments, 9227, 9228.

Mines.
Want of scientific knowledge among persons engaged in mines, 9204.

Newcastle College of Physical Science.
Foundation, &c. of Newcastle College of Science, 9202–9252.
See *Professors, Students, &c.*

Practical Instruction.
Practical scientific instruction best given in workshops; objection to workshops in colleges, 9224, 9225.
Practical instruction in a manufactory, alternated with scientific instruction in a college, desirable in some respects, 9237–9246.

Professors.
Four professors appointed for Newcastle College of Science; the number must be increased, 9210, 9211, 9252.

Armstrong, Sir W. G.—*Professors.*—cont.
Present annual income of Newcastle College of Science will be mainly applied to professors, 9251, 9252.

Science.
Importance of establishing a number of science colleges throughout the country, 9202–9261.
Want of scientific knowledge among manufacturers, engineers, miners, agriculturists, &c., 9204–9206, 9255–9261.
Increasing importance of scientific knowledge felt by employers of labour; contributions to Newcastle College of Science show this, 9217.
Instruction given in Newcastle College of Science should be mainly scientific, 9223–9225.
Practical scientific knowledge is best acquired in actual business; objection to workshops attached to colleges, 9224, 9225.
Local scientific colleges more common on the continent than in England, 9236.
Alternation of practical work in a manufactory and scientific instruction in a college, though desirable, might clash with interests of employers, 9237–9246.

Students.
Students should enter Newcastle College of Science immediately on leaving school, 9208.
Workshops in colleges not desirable for students, 9224, 9225.
Students at Newcastle College of Science might study until 16, and continue their education in evening classes, 9229–9233.
Great number of students in evening classes at Elswick; distinguished students promoted, 9233–9235.
Alternation of manufactory instruction with college instruction might be desirable for students, but not for employers, 9237–9246.
Students who are to engage in business should finish their studies by 16 or 17 years of age, 9242.

ANALYSES OF EVIDENCE

RESPECTING

UNIVERSITY COLLEGE AND KING'S COLLEGE, LONDON, AND OWENS COLLEGE, MANCHESTER.

University College, London.

ROBSON, JOHN, Esq., B.A. (Index of his Evidence.)

Accommodation for Science Purposes.
Museums, laboratories, &c. at University College, London; larger laboratories needed; physical laboratory of great service, 7132, 7134.

Age of Science Students.
At University College School boys begin science at 14 to 15 years of age, 7146–7148.

Apparatus for Science Purposes.
Provision of physical apparatus by University College and School; more wanted, 7134, 7152–7155.

Arithmetic.
In University College School the teaching of arithmetic receives special attention, 7146.

Assistant Professors.
University College wants funds for providing professors with assistants, 7134.

Chemistry.
Birkbeck Chemical Laboratory at University College, London; partly subscribed for by mechanics' institutes; has about 30 students, 7132, 7134.
Chemistry class at University College pays the best; expenses are heavy; special arrangement between council and professor for this class, 7135.
Chemical instruction formerly given to Revenue Department officers at University College, 7142.
Theoretical and practical chemistry is taught in University College School, 7144, 7147, 7151.

Children.
Boys of University College School begin science at 14 to 15 years of age; they have instruction in mathematics, chemistry, physics, economic science, &c., 7143–7158.
500 boys in University College School; a large and increasing number pass into the College, 7149, 7150.

Contributions for Educational Purposes. See *Income and Expenditure.*

Degrees.
The London University enabled students of University College to obtain academical degrees with greater facility, there being no religious test, 7132.
Numerous degrees, &c. gained by former students of University College, 7149, 7150.

De Morgan, Professor.
Successful teaching of mathematics at University College by Professor De Morgan, 7146.

Economic Science.
Economic science is taught at University College School; it was begun by Mr. Shields, 7156–7158.

Fine Arts.
Instruction in the fine arts is now given at University College, 7133.
Liberal contributions made by two members of University College in aid of the Slade School of Fine Arts, 7142.

Government.
No grant from Government has ever been received by University College, London, 7132.
Institutions supported by Government have done harm to University College in drawing away professors, 7136, 7137.
Government aid should be given to University College for training men for public service, 7138–7142.

ROBSON, J., Esq.—cont.

Income and Expenditure.
University College funds; liberal private contributions; 30,000*l.* spent on land, 125,000*l.* on buildings and furniture, nearly 4,500*l.* on library, 16,000*l.* on museums, and 3,000*l.* on chemical laboratory; revenues inadequate for science, 7132–7142.
To 1869, 18,393*l.*, beyond share of fees, was expended on University College; and 10,000*l.* on incomes, retiring allowances, &c. of professors, 7132.
Professors of University College are badly paid; their stipends range from 50*l.* to 600*l.*, averaging about 100*l.* a year, 7135.
Students' fees at University College; expenses of College keep down professors' remuneration, and necessitate high scale of fees, 7135.
Balance of School fees at University College goes to general support of institution, 7143.

Indian Civil Engineering College (Cooper's Hill).
Memorial of University College with respect to the Government competition at Cooper's Hill College, 7138.

Indian Telegraph Department.
Indian Telegraph Department officers have been instructed at University College, without special payment from Government, 7134, 7139.

Laboratories.
Birkbeck Chemical Laboratory at University College cost 3,000*l.*; accommodates about 30 students, 7132, 7134.
Physical laboratory at University College has been of great service, especially to telegraph students, 7134.
Extension of laboratories needed at University College, 7134.
Chemical (but no physical) laboratory for boys at University College School, 7144, 7147, 7151–7155.

Ladies.
Ladies can now receive instruction at University College, 7133.

Languages.
Short time given to classics at University School; many boys learn neither Latin nor Greek, 7145.

Libraries.
Nearly 4,500*l.* was spent in founding the library at University College, 7132.

London University.
"The University of London" was the original title of University College; the College resigned the name without State compensation; College students have benefited in regard to gaining degrees, 7132.

Mathematics.
Mathematical instruction is carried higher at University College School than at most schools, 7144, 7146.
Successful teaching of mathematics at University College by Professor De Morgan, 7146.
University College has always produced an unusual number of good mathematicians, 7149.

Mechanics' Institutes.
The Birkbeck Chemical Laboratory at University College was partly built by subscriptions from mechanics' institutes, 7134.

ROBSON, J., Esq.—cont.

Museums.
Museums of anatomy, materia medica, chemistry, physics, physiology, and zoology, at University College; large sums spent on them, 7132.

Parliament.
Important position gained by "University of London" in 1835, by vote of House of Commons, 7132.
Act of Parliament passed in 1869, for extinguishing proprietary rights and removing certain restrictions in University College, 7133.

Physics.
University College physical laboratory, fitted up at instance of Professor Carey Foster; it has done great service, especially to telegraph students, 7134.
Physics' instruction, with experiments, is given to boys of University College School; there is no laboratory, 7144, 7147, 7152–7155.
Many men now eminent in physical science were formerly students of University College, 7150.

Practical Instruction.
Practical instruction in chemistry and physics is given at University College, 7134.
Practical instruction in chemistry is given to boys of University College School, 7144, 7147, 7151.

Professors.
10,000*l.* expended by University College in aid of professors' incomes, retiring allowances, &c., 7132.
Want of funds at University College for providing professors with assistants, 7134.
Professor of physics at University College devotes much time to few students, 7134.
University College professors are badly paid; their stipends range from 50*l.* to 600*l.*, averaging about 100*l.* a year, 7135.
Instances of University College professors leaving through competition of State-aided institutions, 7136.

Religion.
London University degrees are conferred without religious test; University College students have profited by this system, 7132.

Revenue Department.
Large number of Revenue Department officers formerly instructed in chemistry at University College, 7142.

Science.
Resources of University College are quite inadequate for science purposes, 7134.
Chemistry, physics, economic science, &c. are taught in University College School; boys begin science generally at 14 to 15 years of age, 7143 7158.

Shields, Mr.
Economic science instruction at University College School was begun by Mr. Shields, 7157, 7158.

Slade, Mr.
Slade School of Fine Arts at University College; money given by Mr. Slade's executors was insufficient; supplemented by members of the College, 7142.

Students.
Students of University College, London, have profited from facility of obtaining London University degrees, 7132.
Practical instruction of students in University College laboratories, 7134.
Fees of University College students; expenses of College necessitate a high scale, which tends to diminish number of students, 7135.
Many Revenue Department officers were formerly instructed at University College, 7142.
Numerous degrees, &c. gained by former students of University College, 7149, 7150.

Superannuatiom.
Provision of retiring allowances for University College professors, 7132.

Telegraph Department (*Indian*). See *Indian Telegraph Department.*

University College (*London*).
Promotion of science, &c. at University College, 7132–7158.
See *Professors, Students, &c.*

University College School.
University College School; boys begin science at 14 to 15 years; they learn mathematics, physics, chemistry, and economic science, 7143–7158.
Instruction at University College School differs from many schools; shorter time for classics; parents choose subjects; many boys do not learn Latin or Greek, 7144, 7145.

ROBSON, J., Esq.—*University College School*—cont.
Teaching of arithmetic receives a large amount of attention at University College School, 7146.
500 boys in University College School; a great and increasing number pass into the College. 7149, 7150.

University of London. See *London University.*

WILLIAMSON, DR. ALEXANDER WM., F.R.S.
(Index of his Evidence.)

Apparatus for Science Purposes.
Want of provision for apparatus for chemical instruction and research is a drawback at University College; endowment would remedy this, 7159, 7165, 7166, 7178.

Applied Mechanics.
Chair of applied mechanics at University College is vacant from want of resources; is an important chair, and should be upheld, 7170, 7171.

Assistant Professors, Demonstrators, &c.
Want of provision for assistants in chemical department has been a drawback at University College, 7159.
Professor of chemistry at University College has two assistants, paid for by himself; he also employs senior students, who give their services, 7164.

Bonn.
Good space for students in the laboratories at Bonn, 7185.

Chemistry.
Absence of supplies for assistants, apparatus, &c., for chemical teaching, has been a drawback at University College, London, 7159.
At University College, the chair of chemistry is among the most remunerative; present professor holds two chairs, chemistry and analytical chemistry, 7160–7162.
In department of practical chemistry at University College, there are two regular assistants, besides senior students who assist voluntarily, 7164.
If chair of chemistry at University College were endowed, better apparatus, and means of pursuing research, would result, 7165, 7178.
Professor of chemistry at University College should not be independent of fees, 7166.
General belief that Government chemical appointments are more easily obtained by attending a Government science school, 7181, 7181*a*.
Manufactures open a great career to young chemists; manufacturers' sons study at University College, 7181*a*, 7182.
In Birkbeck Chemical Laboratory at University College the instruction is general, but modified in special cases, 7183–7192.
No text-book is made use of in the chemical laboratory at University College, 7193.
Many teachers of chemistry have been trained at University College, 7194.
Chemical instruction in schools should be given by men who have had practical instruction under professors, 7196-7201.

Engineering.
University College efficiently prepares men for the professional study of engineering, 7170.

Government.
Students from Indian Telegraph and Inland Revenue departments at University College; no special payment received from Government for them, 7168, 7169.
If State aid were given to University College, men could be educated there for special Government departments, 7170, 7171.
Competition of Government institutions with University College; students attend Government institutions in hope of obtaining public appointments, 7176–7181*a*.

Income and Expenditure.
Fees at University College; professor of chemistry provides assistants out of his fees; College mostly takes one third of professors' fees; tendency to raise fees, which is objectionable; a professor should not be independent of fees, 7159–7163, 7166.
Endowment of chair of chemistry at University College would allow provision of better apparatus for teaching and research, 7165, 7166.
For Government men, instructed at University College, no payment beyond the fees has been received, 7168, 7169.

Indian Telegraph Department.
Students sent for instruction in telegraphy from Indian Telegraph Department to University College, 7168.

WILLIAMSON, Dr.—cont.

Inland Revenue.
- Students from Inland Revenue department have received instruction in University College, 7170.

Laboratories.
- For University College chemical laboratory, professor's fees are deducted one fifth instead of one third, 7160.
- In University College chemical laboratory, professor has two assistants, besides students who voluntarily assist, 7164.
- Birkbeck Chemical Laboratory at University College accommodates 24 students; instruction is continued all day; space confined; teaching is general, but modified in view of special professions, 7183–7192.
- More space for students in laboratories at Bonn, &c. than in those at University College, 7185.
- No text-book used in chemical laboratory at University College, 7193.

Manufactures.
- Manufactures afford a great career for young chemists; manufacturers' sons study at University College, 7181*a*, 7182.

Original Research.
- Original research is the higher part of the duties of a professor; endowment of chemistry chair at University College would facilitate this, 7165, 7166.
- No apparatus for original chemical research has been provided by University College, 7178.

Practical Instruction.
- Practical instruction in chemistry at University College; many students voluntarily assist the professor, 7159–7164.
- Advantage of practical instruction in chemistry under a professor to men studying to become teachers, 7196–7201.

Professors.
- Professor of chemistry at University College provides two assistants out of his fees students assist him voluntarily, 7159, 7164.
- University College chemistry professor holds two chairs, chemistry and analytical chemistry, 7161.
- Inducement to University College professors to raise fees, as their source of remuneration; professors are anxious to keep down fees as much as possible, 7163.
- Promotion of original research is the higher part of a professor's duty, 7165.
- Endowments at University College would cause professors to look more to its general interests, 7165.
- Professors of University College, aided by Government, could train men for public appointments, 7170, 7171.
- Professor of chemistry at University College not provided with apparatus for original research, 7178.
- Advantage to students of being engaged in practical work under professors, 7199.

Professorships.
- University College professorship of applied mechanics is vacant; this chair should be upheld, 7170, 7171.

Schools.
- For teaching chemistry in endowed schools, one year's practice in teaching (the subject-matter having been learned) would be sufficient, 7196–7198.
- For teaching chemistry in elementary schools, the master should have previously assisted a professor for three months, 7199–7201.

Science.
- Promotion of chemical science, &c. at University College, 7159 7199.
- Application of scientific principles to professional purposes might be more extended at University College, 7170, 7171.

Students.
- University College students voluntarily aid professor of chemistry in practical department; advantage of this to students, 7164, 7199.
- Indian Telegraph and Inland Revenue departments have sent students for instruction to University College, 7168, 7169.
- Students, and also their parents, choose Government educational institutions in view of public appointments as chemists, &c., 7176 7181*a*.
- For students of chemistry, manufactures afford a great career, 7181*a*, 7182.
- In the Birkbeck Chemical Laboratory at University College, students finishing their instruction receive specially modified teaching, 7183–7192.
- Good amount of space allowed to students in recently built laboratories, 7185.

WILLIAMSON, Dr.—cont.

Teachers.
- Teachers of chemistry have been trained at University College, 7194.

Telegraphy. See *Indian Telegraph Department.*

Text-books.
- No text-book is used in chemical laboratory at University College, 7193.

University College (London).
- Promotion of chemical science, &c. at University College, 7159–7199.
  - See *Professors, Students, &c.*

FOSTER, PROFESSOR GEORGE CAREY, B.A., F.R.S.
(Index of his Evidence.)

Accommodation for Science Purposes.
- University College physical laboratory is unsuitable; thousands of pounds required for proper rooms, 7799–7803.
- Difficulty of providing accommodation for giving instruction in light at University College, 7823, 7824.

Apparatus for Science Purposes.
- Want of apparatus in physical laboratory at University College; laboratory fees cannot supply the want, 7799, 7804, 7836, 7839.
- 200*l*. to 300*l*. a year (suitable buildings being supplied) would suffice for physical apparatus, &c. for University College, 7844, 7845, 7847, 7848.

Assistant Professors, Demonstrators, &c.
- More assistants are required in University College physical laboratory, 7803–7806.
- Willingness of students to act voluntarily as assistants to professors, 7845.
- Assistant teachers (like the German *Privat-docenten*) might be introduced at University College, 7846.

Children.
- Experimental, not practical, lessons in physics, are given to boys of University College School, 7816–7820.

Degrees.
- For London University degrees (except D.Sc.), experimental physics is only required in first B.Sc. and preliminary scientific medical examinations, 7783.
- Examination for London University B.Sc. is not too easy; there is too little physics, 7784, 7790, 7791.
- Physics is amply encouraged in London University D.Sc. degree; no candidate for this degree has studied in University College physical laboratory, 7825–7828.
- For London University B.Sc. degree, the second examination should comprise physics, including practical examination, 7829–7835.

Education.
- Education at University College should be more accessible to the public, 7846.

Electricity.
- Practical instruction in electricity is given at University College, 7823.

Engineering.
- Electric telegraph students in University College have not usually come from engineers' offices, 7842.
- Engineering students should begin with general college studies, and take practical course afterwards, 7843.

Examinations.
- Half the students in the faculties of arts and science at University College are preparing for London University examinations, 7782.
- London University examinations tend to discourage more than an elementary study of physics, 7783.
- Few candidates for London University examinations enter senior physics' class at University College, 7783, 7785.
- University College students have taken high places in Indian Telegraph examinations, 7794.
- Entrance examination desirable for students attending physics' course at University College; the College not able to enforce this, 7813, 7814, 7821, 7822.
  - See *Degrees.*

Germany.
- Teachers like the German *Privat-docenten* might be introduced at University College, 7846.

Government.
- The efforts which have been made by University College and its founders are sufficient to establish a claim to Government aid, 7840, 7841, 7847, 7848.

Foster, Prof.—*Government*—cont.
Competition of Government schools of science has been felt by University College in loss of its teachers, 7854–7856.
University College should be put into a position to offer equivalent inducements to Government educational institutions, 7858, 7859.
Government aid to educational institutions should be given under conditions which would ensure its proper application, 7840, 7860–7863.

Heat.
Practical instruction in heat given at University College, 7823.

Income and Expenditure.
Suitable rooms for a physical laboratory at University College would require thousands of pounds, 7799–7803.
Physics' instruction at University College is seriously impeded for want of funds; income, in addition to fees, essential, 7802, 7812, 7859.
Physics' courses at University College cost 8 guineas each; lately raised; fewer students since; 3 guineas enough, 7808–7810, 7849, 7852.
If total income of chair of physics exceed 300*l.*, professor takes two thirds of fees, 7811.
To organise practical instruction in physics at University College School would be a matter of finance, 7816–7820.
Fees for University College physical laboratory, &c. are too high for thorough utility of institution, 7836–7839, 7846, 7852.
For physics' department at University College (suitable buildings being supplied), 200*l.* to 300*l.* a year would suffice, for apparatus, &c., 7844, 7845, 7847, 7848.

Indian Telegraph Department.
High places taken by University College students in Indian Telegraph examinations, 7794.

Laboratories.
Physical laboratory at University College; too small, and unsteady; apparatus and assistants wanted, 7780, 7799–7806.
Before entering University College physical laboratory, students should undergo examination, 7813–7815.
In University College physical laboratory teaching is chiefly in heat, magnetism, and electricity; difficult to provide for instruction in light, 7823, 7824.
Laboratory instruction in physics essential for candidates for London University D.Sc. degree, 7825–7827.
Want of apparatus in University College physical laboratory; fees will not compensate, 7836, 7839.
18 guineas per session is the fee for University College physical laboratory; shorter periods may be taken; fee should be reduced, 7837, 7838, 7852, 7853.

Light.
Difficulty of providing proper accommodation at University College for giving instruction in light, 7824.

London University.
Half the students in the faculties of arts and science at University College are preparing for London University examinations, 7782.
Examinations of London University do not encourage the higher physics, 7783, 7785.
At London University, except for D.Sc. degree, experimental physics is only required in first B.Sc. and scientific medical examinations; too little physics required, 7783–7785, 7790, 7791, 7829–7835.
London University D.Sc. degree offers ample encouragement for study of physics; no candidate for D.Sc. has yet studied in University College physical laboratory, 7825–7828.

Magnetism.
Practical instruction in magnetism is given at University College, 7823.

Mathematics.
In senior physics' class at University College teaching is mathematical, 7780, 7781.
Class of applied mathematics connected with study of physics at University College, 7780, 7781, 7788, 7789.
Want of mathematical knowledge shown by some students of physics at University College, 7821, 7822.

Medicine.
Physics is required for London University preliminary scientific medical examination, 7783.

Oxford University.
Natural science candidates for degrees at Oxford University undergo practical examination, 7835.

Foster, Prof.—cont.

Physics.
Instruction in physics at University College; several classes; laboratory teaching; class of applied mathematics in connexion, 7779–7789.
London University examinations tend to discourage more than an elementary study of physics, 7783, 7785.
For London University degrees (except for D.Sc.), experimental physics is only required in first B.Sc. and medical examination; too little physics required, 7783–7785, 7790, 7791, 7829, 7835.
Little demand for physics in practical life; demand for teachers in schools, 7792–7796.
Many University College students of physics have entered the Indian Telegraph service, 7793.
Importance of practical instruction in studying physics, 7798.
Physical laboratory at University College is unsuitable, and wants apparatus; thousands of pounds required for proper provision, 7799–7803, 7836, 7839.
More assistants (about half a dozen) required in University College physical laboratory, 7803, 7805, 7806.
Instruction in physics at University College is impeded for want of funds; income, in addition to fees, is necessary; fees too high, 7802, 7807–7812, 7837–7839, 7846–7853.
For University College physics' course an entrance examination would be desirable; College not in a position to enforce this, 7813–7815, 7821, 7822.
Experimental lessons in physics are given at University College School; to give practical instruction would only be a matter of finance, 7816–7820.
Heat, magnetism, and electricity are the chief subjects of study in University College physical laboratory; difficult to provide for instruction in light, 7823, 7824.
Physics is amply encouraged in London University D.Sc. degree; but no candidate has as yet worked in University College physical laboratory, 7825–7828.

Practical Instruction.
Importance of practical instruction in study of physics, 7798.
At University College School practical instruction in physics would be difficult to organise; but it would be a question of finance, 7816–7820.
At University College, the practical instruction in physics is chiefly in heat, magnetism, and electricity; difficult to provide for instruction in light, 7823, 7824.
Practical knowledge should be shown by candidates for London University B.Sc. degree, 7832–7835.
Natural science candidates for degrees at Oxford University have a practical examination, 7835.
For engineering students, practical instruction should follow a general college course, 7843.

Privat-docenten.
Desirable to introduce at University College assistant teachers like the German *Privat-docenten*, 7846.

Professors.
Professor of physics at University College; should have a yearly sum for maintenance of school; has two thirds of fees, when they exceed 300*l.*, 7807–7812.
Professors of physics readily obtain voluntary assistance from students, 7845.
Competition of Government educational institutions is felt by University College in loss of professors, 7854–7856.
University College suffers from a difficulty in offering inducements to well-qualified professors, 7857.

Schools.
Demand for teachers of physics in schools, 7795, 7796.

Science Teachers. See *Teachers.*

Students.
Students of physics at University College have instruction in several classes, besides laboratory work, 7780, 7781.
Half the students in faculties of arts and science at University College are preparing for London University examinations, 7782.
Senior class of physics at University College would be larger if more physics were required for B.Sc., 7783, 7785, 7790, 7791.
In University College physics' classes, senior students number 5 to 8; juniors, 70 to 80; applied mathematics' class 25, 7783, 7786–7789.
Small inducement to students to learn physics; little demand for physics in practical life, 7792.
University College students have stood well in Indian Telegraph examinations, 7793, 7794.
Students of physical science will probably be in demand as teachers in schools, 7795–7797.

FOSTER, Prof.—*Students*—cont.
Number of students at University College diminished by raising fees; fees should be reduced, 7808–7810, 7849–7853.
Students entering physics' course at University College should undergo preliminary examination, 7813, 7814.
Deficiency in mathematics of some students attending lectures on physics at University College, 7821, 7822.
No student in University College physical laboratory has been a candidate for London University D.Sc. degree, 7825–7828.
Candidates for London University B.Sc. degree should have physics in their second examination, and should show practical knowledge, 7832–7835.
Electric telegraph students at University College have not usually come from engineers' offices, 7842.
For students of engineering, practical instruction should follow general college course, 7843.
Willingness of students to act voluntarily as professors' assistants, 7845.

FOSTER, Prof.—cont.
Teachers.
There is a demand for teachers of physics in schools, 7795, 7796.
Men preparing for teachers of physics are glad to act voluntarily as professors' assistants, 7845.
Telegraphy.
Telegraphy opens an important sphere for the application of a knowledge of physics, 7793.
University College students have taken high places in Indian Telegraph examination, 7794.
Electric telegraph students at University College have not usually come from engineers' offices, 7842.
University College (London).
Instruction in physics at University College, 7779–7863. See *Professors, Students, &c.*
University College School.
Experimental lessons in physics are given at University College School; practical instruction would be difficult, but its accomplishment is a question of finance, 7816–7820.

King's College, London.

ADAMS, WILLIAM GRYLLS, Esq., M.A. (Index of his Evidence.)

Accommodation for Science Purposes.
Satisfactory accommodation for teaching physics at King's College, 6886–6889.
Age of Students.
King's College students enter at average age of 16 years, 6929.
Apparatus for Science Purposes.
Physical apparatus at King's College; 300*l.*, and 30*l.* to 40*l.* a year, allowed, 6886–6889, 6967.
Assistant Professors, Demonstrators, and Teachers.
Demonstrators in physics and chemistry at King's College give lectures and practical instruction, 6883, 6958–6961.
Chemistry.
Six lectures on chemistry are given weekly at King's College, besides practical instruction; similar instruction given in the School, 6883, 6920, 6921.
Chemical and physical laboratories at King's College cost together about 2,000*l.*, 6967.
Evening classes at King's College do not much influence education of young manufacturing chemists, 6996.
Children. See *King's College School.*
Cooper's Hill College. See *Indian Civil Engineering College.*
Education.
Defective secondary education an obstacle to scientific instruction at King's College, 6916.
Engineering.
Insufficiency of demand for engineering education, 6880.
King's College applied science department is chiefly for engineering students, 6885–6984.
Before 1866, the demand for engineers here led to neglect of competition for Indian appointments, 6901–6915, 6930, 6938–6948.
If Government had offered inducement, candidates for engineering service would have been found, 6901.
Qualified engineers cannot be expected until students remain longer at places of education, 6905–6907.
King's College engineering students, who have gone to India, have all the training proposed to be given in the Government college, 6908, 6969–6972.
Practice of engineering can only be learned under an engineer, 6969–6972.
King's College might admit students practically engaged in engineering works in London, 6973–6980.
The system of instruction in engineers' offices should cease, 6983.
King's College evening classes do not much influence the education of engineers' apprentices, 6996.
Evening Classes.
King's College evening classes; instruction given by professors, &c.; 500 to 700 students; attempt to give technical instruction, 6883–6996.

ADAMS, W. G., Esq.—cont.
Examinations.
Matriculation examination for King's College, though valuable, would diminish number of students, 6880, 6881, 6925–6928.
Success of King's College students in public examinations, 6892.
Government.
Government students from India sent to King's College for instruction in telegraphy, 6888.
Engineering education would be injured by Government competition with King's College, &c., 6897–6915.
Government grants, &c. should be open to all centres of scientific instruction, 6897, 6898, 6985.
Objection to Government institutions for giving practical instruction in engineering, &c., 6969–6972.
Government technical schools should not be carried on when existing colleges could supply demand, 6969–6972.
Income and Expenditure.
150*l.* per annum the fee at Cooper's Hill College; 150 students estimated to cover expenses, 6949–6955.
In King's College applied science department average fee is 45*l.* per annum, with 10*s.* a term extra, 6962–6964.
King's College chemical and physical laboratories cost about 2,000*l.*; 300*l.*, and 30*l.* to 40*l.* a year, expended in physical apparatus, 6965–6967.
Indian Civil Engineering College (Cooper's Hill).
Cooper's Hill Engineering College would attract King's College students could appointments be gained, 6894.
Objection to Cooper's Hill College, and monopoly of Government patronage, 6897–6915.
King's College students should not have to pass examination for admission to Cooper's Hill College before competing for Indian appointments, 6900.
Three years' course in Cooper's Hill College insufficient for first-rate engineering education, 6906–6908.
Students of Cooper's Hill College, &c. might have their theoretical acquirements fairly tested by examination, 6913, 6914.
Indian Telegraph Department.
Government students from India sent to King's College for instruction in telegraphy, 6888.
Ten King's College students appointed to Indian engineering service in two years, 6892.
Candidates for Indian telegraph appointments have not been forthcoming because insufficient salary was offered, 6901–6904, 6910–6912.
King's College (London).
Promotion of science at King's College, 6878–7001. See *Professors, Students, &c.*
King's College School.
King's College School; under same government as College; lectures and practical instruction in chemistry, &c. are given, 6918–6924.

ADAMS, W. G., Esq.—cont.

Laboratories.
- Physical laboratory at King's College; adapted for instruction in pneumatics, heat, light, electricity, and magnetism; cost (including chemical laboratory) 2,000*l.*, 6883, 6886–6889, 6965–6967.
- King's College chemical laboratory; practical instruction given, 6883.
- In a laboratory, one man might attend to seven or eight students, 6959.

Lectures.
- King's College lectures; mathematics, five days a week; mechanics and physics, four days a week; chemistry, six lectures weekly, 6878, 6883.
- Course at King's College is divided into the classical and modern divisions, 6884.
- For advanced students of physics, practical work might do away with necessity for lectures, 6887.
- Lectures on chemistry and physics are given to boys of King's College School, 6920, 6921.
- Lectures on chemistry, physics, and many other subjects, are given at King's College evening classes, 6991.

London University.
- King's College students have obtained honours at London University; no definite course for this at King's College, 6892, 6896.

Mathematics.
- Small knowledge of mathematics shown by students entering King's College, 6879.
- Lectures on mathematics are given at King's College every day but Saturday, 6883.

Matriculation. See *Examinations.*

Mechanics.
- Lectures on mechanics given at King's College four days a week; also practical instruction, 6883.

Medicine.
- Medical students at King's College have four chemical lectures weekly, besides laboratory instruction, 6883.

Merton College (Oxford).
- Natural science scholarships at Merton College gained by King's College students, 6892.

Natural Philosophy.
- Slight knowledge of natural philosophy shown by students entering King's College, 6879.

Original Research.
- King's College professors have no time to pursue original research, 6882, 6883, 6956–6961.

Physics.
- Lectures in physics are given four days a week at King's College; practical instruction also, 6883.
- King's College physical laboratory is adapted for instruction in pneumatics, heat, light, electricity, and magnetism, 6887, 6965–6967.
- Lectures and practical instruction in physics are given to boys at King's College School, 6920, 6921.

Practical Instruction.
- Practical instruction in physics and chemistry at King's College, the School, and evening classes, 6883, 6886–6889, 6920, 6921, 6991, 6992.
- For advanced students of physics, practical work might do away with necessity for lectures, 6887.
- King's College students learn to use tools, make steam-engines, &c., as well as if they were in an engineering workshop, 6933–6935, 6981–6984.
- No advantage in Government institutions for practical instruction in engineering, &c., 6969–6972.
- At King's College, it is thought better to have theoretical before practical knowledge, 6973–6978.
- Theoretical with practical study contemplated as preparation for Whitworth scholarships, 6979, 6980.
- King's College might arrange to accommodate men in engineering works in London, 6980.

Principals of Colleges.
- Principal of King's College dispensed with marking attendance at chapel; he is empowered to excuse students, 6997–7001.

Professors.
- King's College professors not sufficiently numerous; they have no time for investigation; they are members of the Church, 6882, 6883, 6956–6961, 6987, 6988, 6993.

Religion.
- At King's College, attendance at chapel is voluntary, and not marked; attendance at divinity lectures not insisted on, 6986, 6989, 6997–7001.
- Professors at King's College are understood to be members of the Church of England; no test applied, 6987, 6988.
- King's College is a Church of England institution, 6990.

ADAMS, W. G., Esq.—cont.

Saint John's College (Cambridge).
- Natural science exhibitions at St. John's College, Cambridge, gained by King's College men, 6892.

Scholarships.
- Scholarships at Universities, Whitworth scholarships, &c. gained by King's College students, 6892.

Schools.
- Schools founded by Government should have no advantage over other centres of instruction, 6898, 6985.
- No difficulty in introducing more scientific instruction into secondary schools, 6917.
- Government should not carry on technical schools, when existing colleges can supply demand, 6969–6972.
  - See *King's College School.*

Science.
- Promotion of science at King's College, 6878–7001.
- Defective state of secondary education an obstacle to scientific instruction at King's College, 6916, 6917.

Students.
- Educational standard of students entering King's College is low, 6879.
- Matriculation examination at King's College would diminish number of students, 6880, 6881, 6925–6928.
- King's College medical students have four chemical lectures weekly, besides laboratory instruction, 6883.
- Occasional students at King's College attend special classes; matriculated students have definite courses, 6883, 6884.
- Practical instruction of students of physics at King's College; 24 students last term, 6883, 6886–6890.
- Applied science department at King's College; 75 to 100 students annually; chiefly for engineering students, 6885, 6892, 6893, 6962–6964.
- For advanced students of physics, practical work might supersede lectures, 6887.
- Students at King's College sent by Government from India to study telegraphy, 6888.
- Responsible positions, scholarships, &c. gained by King's College students, 6891, 6892, 6901–6915, 6930, 6938–6948.
- King's College students would be attracted to Government Engineering College were appointments to be obtained, 6894.
- King's College students enter at the average age of 16 years, 6929.
- King's College students learn to use tools, make steam-engines, &c.; many are with mechanical engineers, 6930–6937.
- Theoretical before practical knowledge best for students, 6973–6978.
- King's College students are not obliged to attend chapel or divinity lectures, 6986, 6997–7001.
- 500 to 700 students in evening classes at King's College; most of them in actual employment, 6991–6995.

Technical Instruction.
- At King's College technical instruction in the evening has been attempted, 6996.

Telegraphy.
- Government students from India sent to King's College to study telegraphy, 6888.

Whitworth Scholarships.
- Alternation of theoretical and practical study as preparation for Whitworth scholarships, 6979, 6980.

CUNNINGHAM, JOHN WM., Esq. (Index of his Evidence.)

Accommodation for Science Purposes.
- Museums and dissecting rooms at King's College; special buildings to be provided for practical physiology, 7023, 7027, 7028.

Apparatus for Science Purposes.
- 200*l.* voted by King's College for microscopes for practical physiology, 7039.

Chemistry.
- Chemical instruction and laboratory practice at King's College; 74 students attend the evening classes and laboratory, 7017–7023, 7030.
- King's College has a museum of chemical productions, 7023.

Children.
- 430 boys at King's College School; 15 to 20 enter applied science department of College annually; they have instruction in the workshops, 7033–7036.

Cooper's Hill College. See *Indian Civil Engineerin College.*

CUNNINGHAM, J. W., Esq.—cont.

Evening Classes.
- King's College evening classes; 31 subjects of study; about 300 attend science classes, 7030, 7031.

Examinations.
- No matriculation examination at King's College, except for classifying students, 7036.
- Examinations for Indian appointments not confined to Cooper's Hill College men; this removes objections of King's College, but may make Cooper's Hill College a failure, 7064–7066.

Geology.
- Instruction in geology at King's College; 15 students attend the evening classes, 7018, 7021, 7030.

Government.
- Objection to Government scientific institutions; King's College should have equal patronage and pecuniary advantage, 7043, 7044, 7059.
- Government did not consult King's College before founding Cooper's Hill College; with salaries increased, it could have supplied the want, 7059–7063.

Hospitals.
- Hospital erected by King's College, with a view to clinical teaching, 7038.

Income and Expenditure.
- King's College was erected by money raised by shares and donations; it is poor, 7006, 7037–7042.
- For professorships, prizes, &c., King's College has about 21,500*l.*; ordinary work is paid for by students' fees, 7013, 7014.
- Chief outlay of King's College of late years has been for science, viz., 5,000*l.* for a hospital, 2,000*l.* for a museum, 2,000*l.* for laboratories, 200*l.* for microscopes, and about 1,500*l.* for physiology, 7038, 7039.
- At King's College, teachers receive three fourths, or less, of students' fees of their department, 7041.
- Scheme for raising a fund of 30,000*l.* at King's College; part to be applied in liquidation of 15,000*l.* debt, 7046, 7047.
- With increase of salaries, King's College could have provided what Cooper's Hill College is supposed to furnish, 7059–7063.
- Endowments for scholarships and prizes at King's College amount to 18,000*l.*, 6,600*l.* being unconnected with religion, 7068.

India.
- Examinations for Indian appointments are not to be confined to Cooper's Hill College men, 7064 7066.

Indian Civil Engineering College (Cooper's Hill).
- Objection to Cooper's Hill College, as injuriously affecting King's College, which could have supplied the want, 7043, 7059–7063.
- Examinations for Indian appointments not confined to Cooper's Hill College men; satisfactory to King's College, but may make Cooper's Hill College a failure, 7064–7066.

King's College (London).
- Promotion of science at King's College, 7005–7075. See *Professors, Students, &c.*

King's College School.
- King's College School; 430 boys; 15 to 20 annually enter applied science department of College; instruction given in workshops, 7032–7036.

Laboratories.
- Laboratory instruction given to King's College students, 7021, 7022.
- 2,000*l.* spent by King's College on chemical and physical laboratories, 7038.

Lectures.
- Lectures on chemistry, physics, &c. at King's College; divinity lectures optional, but must be attended for associateship, 7019–7022, 7051, 7052, 7056.

Literature.
- Literature department at King's College is in two divisions, classical and modern, 7015, 7016.
- King's College classical department comprises classics, mathematics, modern history, English, French, and German; modern department, mathematics, natural philosophy, chemistry, history, English, French, German, and geology, 7017, 7018.

Mathematics.
- Mathematical instruction at King's College; 72 students attend the evening classes, 7017–7021, 7030

Mechanics
- Teaching of mechanics at King's College; 35 students attend the evening classes, 7021, 7030.

CUNNINGHAM, J. W., Esq.—cont.

Medicine.
- King's College has a medical department; 140 students; dissecting rooms and library; worked at a loss, 7024–7029, 7040.
- Hospital erected by King's College, with a view to clinical teaching, 7038.

Mineralogy.
- Teaching of mineralogy at King's College; 15 students attend the evening classes, 7021, 7030.
- King's College has a museum of mineralogy, 7023.

Museums.
- King's College has museums of philosophical instruments, of mineralogy and chemical productions, and of anatomy, 7023, 7027.

Physics.
- Teaching of physics at King's College; 20 students attend the evening classes, 7017–7021, 7030.

Physiology.
- Practical physiology to be added to medical department at King's College; provision of apparatus, 7028, 7029, 7038, 7039.
- Teaching of physiology at King's College; 29 students attend the evening classes, 7030.

Practical Instruction.
- Practical instruction in chemistry, physics, &c. given at King's College; practical physiology also to be taught, 7021, 7022, 7028, 7029, 7038, 7039.
- Boys of King's College School have practical instruction in the workshops, 7033.

Principals of Colleges.
- Principal of King's College urges attendance at chapel, but never refuses applications for excuse, 7072–7075.

Professors.
- Professors at King's College have three fourths of students' fees of their department, 7041.
- King's College professors, with increased salaries, could have supplied want of Government as well as Cooper's Hill College, 7059–7063.
- Professors at King's College (except those for Oriental languages, French, and German) are expected to be members of the Church of England, 7069, 7070.

Professorships.
- For professorships, scholarships, and prizes, King's College has about 21,500*l.* left by friends, 7013.

Religion.
- Governing members of King's College are required to be members of the Church of England, 7012.
- King's College classes are open to students of all denominations, 7048–7056.
- At King's College, attendance at chapel is optional, and not marked; about half the members attend, 7048–7056, 7071–7077.
- From divinity lectures at King's College students can be exempted; but they must be attended for associateship, 7051, 7052, 7056.
- King's College class prizes (not endowment prizes) are open without religious test, 7067, 7068.
- Of 18,000*l.* endowment for scholarships, &c. at King's College, 6,600*l.* is unconnected with religion, 7068.
- King's College professors (except those for Oriental language, French, and German) are expected to be members of the Church of England, 7069, 7070.

Scholarships.
- King's College has an endowment of 18,000*l.* for scholarships and prizes, 7013, 7068.

Science.
- Promotion of Science at King's College, 7003–7078.

Students.
- Students' fees support the ordinary work of King's College, 7014.
- About 100 students attend King's College literature department; 80 applied science department; 140 medical department, 7015–7022, 7025.
- Medical students at King's College; 140 attend; hospital, dissecting rooms, &c. provided for them, 7024–7029, 7038, 7040.
- King's College evening classes attended by 550 students, 300 for science; they are generally clerks, engineers, &c., 7030, 7031.
- No matriculation examination for King's College students, except for purpose of classification, 7036.
- Students of all denominations attend classes at King's College; attendance at chapel and divinity lectures not compulsory, 7048–7056, 7071–7077.

CUNNINGHAM, J. W., Esq.—*Students*—cont.
A large number of King's College students have gained honours in Universities, 7058.
Examinations for Indian appointments are to be open to other students besides Cooper's Hill College men, 7064–7066.

Universities.
King's College has one claim to support, from the large number of its students who have gained honours in Universities, 7058.

BARRY, Rev. ALFRED, D.D. (Index of his Evidence.)

Age of Students.
University College School boys leave at a definite age, to enter College; same system proposed for King's College, 7124, 7125.

Architecture.
King's College applied science department prepares for profession of architecture, 7092.

Associateships. See *King's College.*

Cambridge University.
Cambridge University plan of marking attendance at chapel not carried out at King's College, 7088.

Chemistry.
King's College applied science department prepares for profession of chemical manufacture, 7092.

Colleges.
Objection to foundation of Government colleges, 7104.
Existing colleges might supply men for India, if Government paid upon results, 7105–7108.

Divinity. See *Religion.*

Education.
King's College education system comprises the theological, classical, applied science, medical, and modern departments, 7092.
Unfavourable result, educationally, of preponderance of scientific element in training, 7113.

Engineering.
Applied science department at King's College prepares for profession of engineering, 7092.

Evening Classes.
King's College evening classes; lectures in numerous subjects; an expensive department, and heavy burden upon the staff, 7117.
500 or 600 students attend King's College evening classes; they are mostly in offices, &c., 7117–7119.

Examinations.
King's College matriculated students (except those exempted) are expected to pass an examination in divinity, 7085.
Medical department scholarships at King's College have a divinity pass examination, 7091.
If Universities had a matriculation examination involving literature, they might be open to scientific students, 7114–7116.
Matriculation examination at King's College would be difficult, but might be advantageous, 7126, 7127.

Government.
Against Government institutions, King's College would compete at disadvantage; it has equal claims to patronage, 7100, 7101.
Government has conceded open competition for Indian appointments, but inequality between Cooper's Hill College and King's College still exists, 7102–7104.
Objection to foundation of Government colleges, 7104.
Scientific officers for India might be supplied by existing colleges, if Government paid upon results, 7105–7108.
Competition of independent institutions would have a salutary effect upon Government educational institutions, 7112.

Greek.
In the "modern" division of King's College, Greek is not taught, 7092–7094.

Income and Expenditure.
Funds for King's College were given on the faith of its being connected with the Church of England, 7091.
King's College has had great difficulties from insufficiency of resources; medical department involves greatest expense; pecuniary difficulties arise almost entirely from scientific departments, 7095–7099.

BARRY, Rev. Dr.—*Income and Expenditure*—cont.
General expenses at King's College are met by one fourth of fees; three quarters going to teaching staff, 7096.
If Government contributed to existing colleges payment upon results, they could supply officers for India, 7105–7108.

India.
Scientific officers for India could be supplied by existing colleges if they had payment on results, 7105–7108.

Indian Civil Engineering College (Cooper's Hill).
Memorial of King's College, urging equal right to Government patronage with Cooper's Hill College, 7101.
Notwithstanding concession of open competition for Indian appointments, there is still inequality between Cooper's Hill College and King's College, 7102, 7103.

King's College (London).
Promotion of science, &c., at King's College, 7080–7127. See *Professors, Students, &c.*

King's College School.
King's College School is divided into classical and modern departments; it trains boys for the College, 7092.
To make King's College School a greater feeder to the College, a limitation of age has been proposed; the School overlaps the College, 7124.
Objection to sending ill-prepared candidates for King's College into the School, 7125.

Latin.
Latin is taught in the "modern" division of King's College, but may be discontinued, 7092–7094.

Lectures.
Lectures at King's College; students exempted from divinity lectures on ground of conscience, 7080–7127.

Literature.
Necessity of admixture of literary element in scientific teaching, 7113.
Universities might be open to scientific students, with a matriculation examination involving literature, 7114–7116.

Matriculation. See *Examinations.*

Medicine.
Medical department scholarships at King's College have a divinity pass examination; dispensed with on conscientious grounds, 7091.
King's College medical department prepares for professions of medicine and surgery, 7092.
At King's College, the medical is the most expensive department, 7099.

Museums.
Great expense of the anatomical museum at King's College, 7099.

Principals of Colleges.
Principal of King's College; exempts students, on conscientious grounds, from attendance at chapel; he does not know who attends, 7079–7082, 7086–7088.

Professors.
Professors, &c. at King's College (except those for foreign languages) are required to be members of the Church of England, 7083–7085.
No lack of excellent candidates for professorial appointments at King's College, 7085.
Evening classes at King's College entail a heavy burden upon professors, 7117–7119.

Religion.
King's College students are expected to attend chapel, but are excused on ground of conscience; attendance not marked, 7080, 7082, 7085.
Neglect of religious instruction at King's College by students does not affect their progress, 7082.
Charter of King's College requires teaching staff (except foreign masters) to be members of the Church of England; a simple statement sufficient, 7083–7085.
Matriculated (not occasional) students at King's College must attend religious instruction, unless reason be shown for non-attendance, 7085, 7086.
Religious lectures at King's College are mostly scriptural; occasionally on the Prayer Book, 7085.
About three per cent. of King's College students are exempt from religious teaching, 7087.
Next King's College calendar will have the rule requiring attendance of students at chapel altered to "expected to attend," 7088.
King's College always a Church of England college; succeeding University College, founded on different principles, 7089, 7090.

Barry, Rev. Dr.—*Religion*—cont.
- Endowments and exhibitions at King's College (except in theological department) are open to persons not members of Church of England, 7091.
- King's College theological department trains for the ministry of the Church of England, 7092.
- Students at King's College are rejected most stringently in the theological department, 7127.

Royal School of Mines.
- Instances of students going to Royal School of Mines in preference to King's College, on score of economy, 7120, 7121.
- Scholarships, like those at the Royal School of Mines, desirable for King's College, 7122, 7123.

Scholarships, Exhibitions, &c.
- Endowments, &c. at King's College are open to persons not members of Church of England, 7091.
- Medical department scholarships at King's College have a divinity pass examination for students not claiming exemption, 7091.
- Scholarships like those of Royal School of Mines would be an advantage to King's College, 7122, 7123.
- New scholarships to be established in applied science department at King's College, 7123.

Schools.
- Public schools ought to send out students of science able to pass a University matriculation examination, 7116.

Science.
- Promotion of science at King's College, 7080–7127.
- Predominance of scientific element in training not favourable to mental development, 7113.
- If Universities had a matriculation examination involving literature, their teaching, &c. might be open to scientific students, 7114–7116.

Science and Art Department.
- Science and Art Department scholarships, like those at Royal School of Mines, would be a great help to King's College, 7122, 7123.

Students.
- King's College students are expected to attend chapel; excused on conscientious grounds; attendance not marked, 7080–7082, 7085–7088.
- At King's College, occasional students receive religious instruction optionally; matriculated students are expected to attend the divinity lectures, &c., 7085.
- About three per cent. of King's College students are exempt from religious instruction, 7087.
- Endowments, &c. open to King's College students not members of the Church, 7091.
- King's College medical students have a divinity pass examination for scholarships; they can claim exemption, 7091.
- "Modern" division students at King's College have Latin at present, but no Greek, 7092–7094.
- More general culture shown by King's College students in literature than in applied science, 7113.
- Predominance of scientific element in training not favourable to education of students, 7113.
- Universities should be open to science students, after a matriculation examination involving literature, 7114–7116.
- 500 or 600 students attend King's College evening classes; they are mostly in offices, &c., 7117–7119.
- Preference given by students to Royal School of Mines over King's College, on score of economy, 7120, 7121.
- King's College School boys proposed to be passed into the College at a specified age, 7121.
- Matriculation examination for King's College, &c. might raise standard of students, 7126, 7127.
- Many students rejected at King's College, especially in theological department, 7127.

Universities.
- With a matriculation examination involving literature, teaching, &c. of universities might be open to scientific students, 7114–7116.

University College (London).
- Boys pass from University College School into the College at a specified age, 7121.

DUNCAN, PETER MARTIN, Esq., M.B. Lond., F.R.S.
(Index of his Evidence.)

Age of Students.
- Men of 50 years of age sometimes attend the evening geological lectures at King's College, 7619.
- Students should not begin geology till their 19th year, 7702.

Duncan, P. M., Esq.—cont.

Apparatus for Science Purposes.
- Insufficient apparatus for teaching geology at King's College, 7639–7641.

Artizans.
- Artizans do not attend King's College evening classes; cheap elementary course desirable, 7649–7654.
- Government competition with King's College for giving instruction to artizans is very slight, 7655, 7656.

Astronomy.
- Astronomy essential to study of geology; deficiency of King's College students in this matter, 7629, 7630.

Biology.
- Biological course for applied science and modern departments at King's College desirable; it should be given at present by professor of geology, 7666–7669, 7689, 7690.
- Medical and evening-class departments at King's College have biological instruction, 7691, 7692.
- Comparative anatomy, with reference to palæontology, should be taught to King's College students of geology, 7694, 7695.

Chemistry.
- Chemical knowledge essential to success in geology, 7625–7628.

Council of Scientific Advice.
- Scientific council of advice desirable for Government, 7704–7710.

Degrees.
- Want of knowledge of geology shown by candidates for London University B.Sc. degree, 7674, 7675.

Endowments. See *Income and Expenditure.*

Engineering.
- Engineering students at King's College have to attend the lectures on geology, 7585.
- Most of the King's College applied science department students become engineers, 7699, 7700.

Evening Classes.
- King's College evening classes for geology; 18 lectures given; examinations, prizes, &c., 7583–7588, 7613–7620.
- Difficulty of knowing what to teach in evening classes on geology at King's College; results unsatisfactory, 7648–7653.
- Artizans do not attend King's College evening courses on geology; cheap elementary course desirable, 7649–7656.
- Comparative anatomy, botany, and physiology are taught in King's College evening classes, 7691.

Examinations.
- Annual examinations for applied science department at King's College; marks published, and prizes given, 7599, 7600.
- Voluntary examination follows evening course on geology at King's College; results not published, 7613–7620.
- Best examinations in geology at King's College are passed by those best grounded in foundation subjects, 7625.

Geography (Physical).
- Physical geography essential to study of geology; deficiency of King's College students in this respect, 7629, 7630.
- Physical geography, or physical geology, should be taught in schools, 7703.

Geological Survey (United Kingdom).
- Exactness of the Geological Survey maps; constant use of them in teaching geology at King's College, 7597.

Geology.
- Teaching of geology at King's College; three separate courses of lectures; 52 lectures given; 135 students last year, 7583–7597.
- Geology forms part of curriculum of engineering students at King's College, 7585.
- Applied science department students at King's College attend about 70 lectures on geology, 7590–7594, 7621–7625.
- Modern department students at King's College obliged to attend geology lectures, 7601–7612.
- Evening lectures on geology at King's College; prizes, &c. awarded; results not published; difficult to conduct, 7613–7620, 7648–7653.
- Success of students of geology depends upon a knowledge of mathematics, physics, and chemistry, 7625–7628, 7637, 7638.
- Geological education at King's College might be restricted to second and third years' men; lectures might be confined to one year, 7631–7634, 7659.

DUNCAN, P. M., Esq.—*Geology*—cont.
Want of apparatus for teaching geology at King's College; insufficient grant, 7639–7647.
Desirable if King's College professor of geology gave a course on biology, 7666–7669, 7689–7691, 7694, 7695.
Deficiency of geological knowledge shown by London University candidates for degrees, 7674, 7675.
Geology would be better taught if professors were better paid, 7676–7680.
Geology should not be taught to students under 19, 7702, 7703.

Government.
King's College has never received Government assistance, 7642, 7643, 7693.
Government should grant endowments to King's College, &c.; advancement of science would result; amount required would not be great, 7681–7688, 7701, 7710.
Government aid should be given to institutions in which private exertion had been made, 7696.

Income and Expenditure.
Want of funds at King's College for teaching geology, &c.; insufficient grant, 7639–7647, 7657, 7676–7680.
King's College receives no endowment from Government, 7642, 7643, 7693.
Government endowments should be awarded to King's College and similar institutions, 7681–7688, 7696, 7710.

King's College (London).
Teaching of geology, &c. at King's College, 7583–7712. See *Professors*, *Students*, *&c.*

Lectures.
Lectures on geology and palæontology at King's College; three separate courses; 52 lectures given, 135 students attended last year, 7583–7594.
Students of applied science department, King's College, attend about 70 lectures, 7594.
King's College lectures on geology include its relation to practical mining, 7595–7597.
Evening lectures on geology at King's College; not desirable to continue them, 7613–7620, 7648–7656.
King's College lectures on geology might be restricted to second and third year's men, and the course confined to one year, 7631–7634, 7659.
Cheap elementary lectures to artizans desirable at King's College, 7648–7656.

London University.
Imperfect geological knowledge shown by London University B.Sc. degree candidates, 7674, 7675.

Mathematics.
Mathematics essential to successful study of geology, 7625–7628.

Medical.
Except in medical department, there is no regular biological instruction at King's College, 7691.

Mining.
Relation of geology to practical mining is taught at King's College, 7595–7597.
Lectures of Professor Smyth taken as the groundwork of the mining lectures at King's College, 7597.

Museum of Practical Geology.
Museum of Practical Geology has granted specimens to different educational establishments, 7644–7646.

Palæontology. See *Geology.*

Physics.
Physics essential to study of geology, 7625–7628.

Practical Instruction.
Extension of practical instruction would result from better payment of professors, 7697, 7698.

DUNCAN, P. M., Esq.—cont.

Professors.
If professors were better paid, the teaching would be better, 7657, 7676–7680, 7697, 7698.
Professor of geology at King's College; he devotes much time to his duties; all his time, except that given to research, should be occupied, 7661–7665.
Biological course desirable at King's College; to be given by the professor of geology, 7666–7669, 7689–7691, 7694, 7695.
Professors at King's College should have endowment, and retiring pensions, or fees, 7681–7685.
With Government endowment at King's College, appointments should be made by a scientific board, chosen from scientific societies, 7704–7710.
Professors of King's College must be members of the Church of England; theological curriculum liberal; no difficulty in providing professors, 7705–7712.

Professorships.
Professorships at King's College, &c. should be endowed by Government, 7681–7688.

Religion.
Exemption from religious instruction at King's College has developed a new class of students, 7636.
King's College professors must be members of the Church of England; no difficulty in providing professors, 7705–7712.
Theological curriculum at King's College much more liberal than formerly, 7710.

Schools.
Geology proper is not a subject for schools, 7703.

Science.
Award of Government endowment to King's College, &c. would lead to advancement of science, 7688.

Scientific Societies.
Board of scientific advisers for administration of Government endowments, and appointment of professors, desirable, 7704–7710.

Smyth, Professor.
Professor Smyth's lectures are taken as the groundwork of the mining lectures at King's College, 7597.

Students.
Geological lectures at King's College; attended by engineering and modern department students, evening class men, and occasional students, 7583–7594.
Geological course at King's College must be attended by applied science department students; the greater part become engineers, and get appointments, 7590–7594, 7621–7625, 7699, 7700.
King's College modern department students attend geological lectures optionally, 7601–7612.
Evening classes on geology are attended by students outside the regular college students, 7613–7620.
Success of students of geology depends upon previous knowledge of mathematics, physics, and chemistry, 7625–7628, 7637, 7638.
Geological instruction at King's College might be restricted to second and third year's students, and course confined to one year, 7631–7634, 7659.
If King's College professors were freed from difficulties, students would increase in number, 7657.
Students should not begin to study geology till their 19th year, 7702.

Superannuation.
Retiring pension desirable for professors of King's College, &c., 7681–7685.

University College (London).
If professors of geology at University College were better paid, teaching would be better, 7677, 7678.

University of London. See *London University.*

Owens College, Manchester.

GREENWOOD, J. GOUGE, Esq. (Index of his Evidence.)

Accommodation for Science Purposes.
Demand for, led to Owens College extension movement, 7265.

Act of Parliament.
Incorporation of Owens College granted by Act of last year, 7270, 7273.

GREENWOOD, J. G., Esq.—cont.

Age of Science Students.
At Owens College, students range from 14 to 24 years of age and upwards, 7251, 7359.

America.
Multiplying degrees in, has lessened their value, 7351.

GREENWOOD, J. G., Esq.—cont.

Artizans.
- Manchester Working Men's College absorbed in Owens College evening classes, 7251.
- Whitworth exhibitions held by artizan candidates for Whitworth scholarships, 7283.
- One or two holders of Rumney artizan scholarship in Owens College; more may be expected, 7287.
- Case of an artizan foregoing a Department exhibition, because he had to hold it in London or Dublin; objections to this plan, 7287, 7348–7350.
- Desire in Manchester, &c. for increased scientific education for artizans, 7300.
  - See *Working Classes.*

Berlin University.
- Introduction of science in, 7255.

Cambridge University.
- Introduction of science in, 7255.

Chemistry.
- Rapid development of chemistry branch of Owens College, 7253.

Contributions for Science Purposes.
- Amounts subscribed for Owens College, and for its extension, 7258, 7266. Half has been subscribed by a few individuals, 7298.

Cost of Science Instruction. See *Owens College.*

Degrees.
- Multiplication of degrees in America and Germany has lessened their value, 7351.
- In any University giving degrees, there should be competition between different educational institutions, 7357, 7358.
  - See *London University. Owens College.*

Elementary Schoolmasters.
- Owens College a fortunate centre for instructing, 7338, 7344. Their instruction would be chiefly in evening classes, 7347.
  - See *Science Teachers.*

Endowments for Science Purposes. See *Owens College.*

Evening Science Classes.
- Establishment and success of, at Owens College. Working Men's College absorbed in them, 7251.
- Five-sixths of the students are of the working class, including under this term warehousemen and clerks in offices, 7294.

Fees.
- Fees at Owens College compared with those at University College, &c., 7258–7263.

Göttingen.
- Introduction of science in University of, 7255.

Germany.
- Introduction of Science into the old universities of Germany, as well as in special schools, 7255.
- Multiplying degrees in Germany has lessened their value, 7351.

Government Grants in aid of Science.
- Applications for, from Owens College. Government control over college, in consideration of grant, a fair matter of negotiation, 7266–7269, 7271, 7272, 7276–7279.
- Conditions under which State aid might be granted to Owens College, &c., 7269, 7308–7318.

Heidelberg.
- Introduction of science in University of, 7255.
- Lectures given in the classical seminarium at, by members of higher teachers' class to lower, 7296, 7328.

Huxley, Professor.
- Valuable scheme of evening science instruction for Owens College proposed by, 7292.

Laboratories.
- Cost of proposed laboratory for Owens College, 7267.

Lancashire.
- Increased desire in, for scientific education of the industrial classes, 7300.
- Larger number of Science and Art Department classes in, than in any similar area in England, 7339.

Literature.
- Study of, should be combined with science, in one institution, 7254, 7319–7327, 7360, 7361.

GREENWOOD, J. G., Esq.—cont.

London University.
- Owens College studies adapted for degrees of, 7257. More students go to, than to the old universities, 7342, 7343.
- Approval of degrees being given by, to Owens College students, 7351, 7352. Might be made more public, if London University held an occasional session in Manchester, 7352, 7356.

Magnus, Professor.
- Opinion of, quoted, as to science teaching and technical instruction, 7283.

Manchester.
- Necessity for science being taught in, even more than in London, &c., 7253, 7254.
- Meeting at, to forward Owens College extension, 7266.
- Desire in Manchester for increased scientific instruction for industrial classes, 7300.
- Site in, for Owens College, 7301–7307.
- Large amount of science teaching in Manchester district, 7338, 7339.
- Advantage of its position for students, 7340, 7341.

Method. See *Professor of Method.*

Owens College.
- Witness is principal of, 7250.
- Foundation, students, evening classes, &c., of, 7251, 7359.
- Locality of, has had a marked influence on the education provided in, 7253.
- Advantage of combination of literature and science studies in. Students select subjects of study, 7254–7257, 7319–7327.
- Endowments, fees, &c. in, 7258–7263.
- Application from College to Government, 7266–7269.
- Growth of science department in; Owens College extension, 7264–7282, 7301–7307.
- Conditions under which State aid might be granted to, 7269, 7308–7318.
- Artizan students in, holders of Rumney scholarships; two-fifths of students are sons of Manchester warehousemen, &c.; many from surrounding districts, 7287–7291. Few go to old universities; most go to London University, 7342, 7343.
- Case of artizan student in, who relinquished a Government exhibition because he was obliged to go to London or Dublin; objection to this system, 7287, 7348–7350.
- Success of evening classes in the College; 527 attend; means of methodizing instruction incomplete, 7292–7294.
- Valuable system of evening instruction in the College proposed by Professor Huxley, but funds insufficient to carry it out, 7292.
- Payment on results by Department would not cover expenses of evening classes in, 7293.
- A special class might be held in, for those likely to become teachers, 7295, 7296.
- The College fund is considerable, and has been subscribed by a few individuals, 7298.
- A professor of method in the College desirable, but he should be an assistant professor, 7331–7337.
- Owens College a good centre for instruction of schoolmasters; positions of some so instructed, 7338–7341, 7344–7347.
- Inexpedient for the College to grant degrees: the London University does the work effectually, but might hold a session in Manchester, 7351–7358.

Oxford University.
- Introduction of science in, 7255.

Professor of Method.
- Would be desirable in an institution, but he should be as an assistant, 7331–7337.

Royal School of Mines.
- More than one such centre of the highest scientific teaching should be provided, 7629.

Rumney Scholarships. See *Scholarships.*

Scholarships.
- Admirable scholarships founded by Mr. Rumney, for artizans; must be held now in Owens College, 7287.
- Great impulse given to study of science by exhibitions of Sir J. Whitworth, 7283, 7285.

Science.
- With literature, should be studied in one institution, 7254, 7319–7327, 7360, 7361.
- Necessity for science in Manchester greater than in London, &c., 7254.

GREENWOOD, J. G., Esq.—*Science.*—cont.

High value of science as culture and discipline, 7254.
Danger of the application of science becoming more regarded than science itself, 7254, 7283.
Higher scientific instruction not self-supporting, 7269.
Introduction of science into English and German universities, 7255.
Desire in Manchester district for increased scientific education of industrial classes, 7300.
See *Owens College.*

Science and Art Department.
Owens College would be glad to avail itself of the 25*l.* offered by, on condition of a like sum being raised, 7284–7286.
Case of an artizan who had to forego a Department exhibition because it was to be held in London or Dublin; objection to this plan, 7287, 7348–7350.
Larger number of Department classes in Lancashire than in any similar area in England, 7339.

Science Students.
Students of all classes derive benefit from the study of science, 7254.
See *Owens College.*

Science Teachers.
Best training for, is under good professors; instruction in a normal college has advantages, but also defects, 7295.
Might be trained to method in Owens College, as at Heidelberg, 7295, 7296, 7328–7330.
Teachers might practice teaching in Manchester, if there were a gradation of schools there, 7331–7333.
A teacher of method desirable in an institution, but he should be an assistant, 7334–7337.
Owens College a fortunate centre for instructing teachers, 7338–7341, 7344–7347.
Positions held by science teachers trained in Owens College, 7345.

Society of Arts.
Definition of "technical training," in a paper of Society of Arts, 7283.

Technical Instruction.
Danger of science being sacrificed to technical instruction, 7283.

Training Colleges.
Teaching in normal colleges has advantages, but also defects, 7295.

Whitworth Scholarships. See *Scholarships.*

Working Classes.
Five-sixths attending Owens College evening instruction are of the working classes, including warehousemen and clerks in offices, 7294.
See *Artizans.*

Working Men's College, Manchester.
Absorbed into Owens College evening classes, 7251.

ROSCOE, HENRY ENFIELD, Esq., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
Inadequate chemical laboratory at Owens College; complete one provided in new building, as well as dissecting rooms, workshops, &c., 7369–7376.
Extensive laboratories and other buildings devoted to science at Berlin, Bonn, Leipzig, &c., 7384, 7385, 7389, 7390, 7406.

Age of Science Students.
For entrance in German universities, 18 years, 7389.
Artizan students in Owens College are 20 to 22 years of age, 7411.

Artizans.
Scientific principles must be taught to youths; through want of time and knowledge of principles, artizans are difficult to instruct, 7394.
Demand for science instruction by artizans; these make the best students, 7408.
Whitworth scholarships gained by, but not confined to, artizans, 7409, 7410.
In Owens College, artizan students are from 20 to 22 years of age, 7411.
Lectures, classes, &c. for artizans in Manchester, 7431.

Arts.
Objection to teaching arts or manufactures; sound principles of science the first essential, 7367.

Berlin.
Science instruction at, 7384, 7385, 7389, 7391.

ROSCOE, H. E., Esq.—cont.

Bonn.
Science instruction at, 7384, 7385, 7389, 7391.

Brackenbury, Miss.
Contribution by, for incorporating Manchester School of Medicine with Owens College, 7377.

Calico Printing. See *Lancashire.*

Carlsruhe.
Science instruction in, 7389.

Chemistry.
Fees for science course in Owens College; chemistry fees lower than in London, 7364, 7365.
Many Owens College chemistry students enter without any knowledge of the subject, 7366.
An assistant professor should be provided for every 20 students, 7389.
The greatest chemical discoveries in Germany have resulted from pure, not applied, science, 7390. The most important chemical schools have been in the universities, 7391.
Advantage of having intermediate instruction between Owens college chemistry classes and ordinary colour shops; but instruction difficult to devise, 7393–7401.
Instruction in chemistry, &c. should be directed by one professor, assisted by subordinate men, 7404.
Dalton scholarships for original research in chemistry at Owens College, 7412–7416, 7419, 7420.
List of original investigations in chemistry, made in Owens College laboratory, 7422.

Colour Shops.
Instruction wanted between Owens College chemistry classes and ordinary colour shops, 7393–7401.

Continental Science Schools. See *Science Schools (Continental).*

Contributions for Science Purposes.
Donation of 10,000*l.* by Miss Brackenbury towards incorporation of Manchester School of Medicine with Owens College, 7377.

Cost.
Cost of new laboratories and other buildings at Owens College, 7369, 7377.
Cost, in Germany, of laboratory fees, and erecting and working laboratories; salaries of professors and assistants, and apparatus; buildings, &c., 7384, 7385, 7389, 7406.
Cost to Government of science colleges would be repaid in proper training of science teachers, 7435.

Council of Scientific Advice.
Desirability if forming, to assist Government; should not consist solely of men of science, 7436–7349.

Dalton Scholarships.
For original research in chemistry; not much competition for, at Owens college, 7412–7416, 7419, 7420.

England.
Compared with Germany, &c., as to science instruction, 7384–7387, 7403.

Fees.
For science courses at Owens College; chemistry course lower than in London, 7364, 7365.
For laboratory instruction, &c., in Germany; lower than in England, 7384, 7389.

Freiberg.
Mining academy at Freiberg, and connected Free Mining School at Zwickau, 7389.

French Language.
Necessity of studying, in connexion with science course, 7364.

German Language.
Should be studied, in connexion with science course, 7364.

Germany.
Science teaching in Germany compared with England; larger number of teachers; more effective instruction of students; fees lower; large sums spent on laboratories, &c., 7384–7387, 7389, 7402–7406.
Relation between German universities and polytechnic schools, and distinction between science instruction therein; relation of these to Government, 7389–7392.
Seminaria in, 7389.
The most important chemical schools of Germany have been in the universities, 7391.
Peculiar system of teaching in Germany; not entirely applicable to England, 7402, 7403.

ROSCOE, H. E., Esq.—cont.
Employment formerly of chemists from Germany in chemical works round Manchester, 7407.
German university system, rather than the polytechnic school, a model for England, 7430.

Giessen.
School of chemistry in university of, 7391.

Göttingen.
Science instruction at, 7384, 7389.

Government.
Relation between Government and academical bodies in Germany, 7389, 7406.
Scholarships of, less desirable than those founded by private munificence, 7417.
Institutes providing physical laboratories have a claim on Government, 7418.
Government can best aid science by foundation of professorships, and by helping what is now going on, 7425–7429.
Cost to Government of science colleges would be repaid in proper training of science teachers, 7435.
A consultative science council desirable, to advise Government on matters of scientific instruction, 7436–7439.

Government Grant Committee. See *Royal Society.*

Heidelberg.
Science instruction at, 7384, 7389, 7391, 7402.

Hofmann, Dr.
Allusion to report of, on German laboratories, 7385.

Huxley, Professor.
Popular science lecture by, at Manchester, 7431.
Important proposition by, for systematizing evening science instruction in Owens college, 7431.

Laboratory.
Chemical laboratory at Owens college inadequate; new laboratories in progress; laboratory fees, &c., 7364–7376.
Cost of construction, working expenses, &c., of chemical laboratories of Berlin, Bonn, Leipzig, &c., 7384, 7385, 7389–7391, 7406.
Advantage of instruction between Owens college chemical laboratory and ordinary colour shops, 7393–7401.
Former employment of German chemists in English laboratories, 7407.
Many students from Owens College chemical laboratory now occupy positions of trust, 7407.
Dalton scholarships must be held one year in Owens College, and another in some other college, 7413.
Professor Balfour Stewart on physical laboratories, 7418.
List of original investigations made in Owens College laboratory, 7422.

Lancashire.
Calico printers, &c., of Lancashire would benefit if instruction could be devised between Owens College chemistry classes and ordinary colour shops, 7393–7401.
Special need for high scientific instruction in Lancashire, 7407.

Leipzig.
Science instruction in, 7384, 7389, 7391.

Lockyer, Mr. Norman.
Popular science lecture by, at Manchester, 7431.

London.
Approval of bringing science teachers to London for instruction, 7433, 7434.

London University.
Special course of study in Owens College for London University degrees, 7364.

Manchester.
Royal School of Medicine in, to be attached to Owens College, 7376–7379.
Manchester is a centre where are carried on most important industries depending on science, 7407.
Positions of trust in Manchester Chemical Works filled by Owens College students; Germans formerly appointed to these posts, 7407.
Scientific instruction in Manchester; lectures by Professor Huxley, Mr. Norman Lockyer, &c., and science classes, 7431.

Manufactures.
Objection to teaching arts and manufactures; sound principles of science the first essential, 7367

ROSCOE, H. E., Esq.—cont.
Medical School. See *Royal School of Medicine, Manchester.*

Meteorology.
Advantage of a physical laboratory in connexion with, 7418.

Mining Schools. See *Science Schools.*

Munich.
Science instruction in, 7389.

Original Research.
Teachers of science should pursue original research, 7421.
List of original chemical investigations made in Owens College laboratory, 7422.
Best way of promoting original research, 7425.
Foundation of high-class science schools would tend to increase original research, 7428.

Owens College.
Witness is professor of chemistry in, 7363.
Students and their subjects of study in Owens College; a distinct course for London University science degrees, 7364. Students in chemical laboratory, 1870–71, and chemistry classes since foundation, 7365, 7366. Positions of trust held by students, 7407.
Fees for science courses in the college; lower than in London; higher than in Germany, 7364, 7365, 7384.
Inadequate chemical laboratory accommodation in Owens College; new laboratory building; its size, cost, &c., 7369–7373. New buildings will accommodate natural philosophy, engineering, and natural history departments, with workshops and dissecting rooms for students, &c., 7373–7376, 7381, 7383.
Manchester Royal School of Medicine proposed to be attached to Owens College, 7376–7379.
Report to Owens College Extension Committee on continental science schools, 7389.
Instruction desirable between Owens College chemistry classes and colour shops, but difficult to devise, 7393–7401.
Subdivision of professorships in Owens College, 7404, 7405.
Demand for science instruction in Owens College by artizans, 7408–7411.
Whitworth, Dalton, and Rumney scholarships in Owens College; additional scholarships desirable, but they should be founded by private munificence, 7409, 7410, 7412–7417, 7419, 7420.
List of original chemical investigations made in Owens College laboratory, 7422.
Systematization of scientific instruction in Owens College proposed by Professor Huxley, 7431.

Physics.
Instruction in physics should be directed by one professor assisted by subordinates, 7404.

Polytechnic Schools. See *Germany.*

Practical Instruction.
In continental schools of science; comparison with those of England, 7384, 7389.

Privat-docenten. See *Science Teachers.*

Professors. See *Science Teachers.*

Professorships.
Foundation of professorships in science the best aid that could be rendered by Government, 7425–7429.
See *Science Teachers.*

Repetiteurs. See *Science Teachers.*

Report.
Of Dr. Hofmann and of M. Wurtz, on German laboratories, 7385.
To Owens College Extension Committee on continental science schools, 7389.

Royal College of Chemistry.
Fees for laboratory instruction in, compared with Owens College, 7364.

Royal School of Medicine, Manchester.
Contemplated attachment of, to Owens College; Miss Brackenbury's contribution for this purpose, 7376–7379.

Royal School of Mines.
Cost of instruction in, compared with Owens College, 7364, 7365.

Royal Society.
A body similar to Government Grant Committee of, is required, to furnish funds for physical purposes, 7418.

Roscoe, H. E., Esq.—cont.

Rumney Scholarships.
In Owens College; remission of candidates' fees by professors, 7412.

Scholarships. See *Science.*

Science.
Special course in Owens College for London University degrees, 7364.
French and German should be studied in connexion with science, 7364.
Importance of foundation of sound scientific principles; application easy, 7367.
The higher scientific instruction can never be self-supporting, 7382.
England and the continent in respect to scientific instruction, 7384–7387, 7403.
Difficulty of instructing artizans in science, 7394.
Science scholarships in Owens College; more desirable, 7409–7417, 7419, 7420.
Little encouragement now to science; Government should found professorships, and high-class science schools, 7425–7430.
Science lectures, classes, &c., in Manchester, 7431.
Department science instruction in Lancashire still imperfect, 7432.
Desirability of a consultative science council, to advise Government, 7436–7439.

Science and Art Department.
Dr. Hofmann's report to, on chemical laboratories, 7385.
Department science instruction in Lancashire still imperfect, 7432.
Objection to Department system which allows a man to teach after passing one examination, 7435.

Science Classes. See *Science.*

Science Examinations.
Objection to Department system of, which allows a man to teach after passing one examination, 7435.

Science Schools (Continental).
Report on universities and high schools of science of Bonn, Göttingen, Berlin, Leipzig, Freiberg, Heidelberg, Carlsruhe, Munich, and Zurich, 7384–7389, 7402–7406.
See *Science.*

Roscoe, H. E., Esq.—cont.

Science Students.
Effective instruction for, in continental schools, 7384–7389.
Difference between class of students attending universities and polytechnica of Germany, 7390.
See *Owens College.*

Science Teachers.
More professors and assistants in Germany than England; professors in universities are of three grades, professor ordinarius, professor extraordinarius, and privat-docens; advantage of these competing with each other, &c., 7384–7389, 7402, 7403, 7406.
Subdivision of professorships in Owens College, 7404.
Fees remitted by professors in Owens College for Rumney scholarship candidates, 7412.
Claim on Government of professors in physical laboratories, 7418.
Teachers of science should have leisure for original research; this can be effected if they are assisted by répétiteurs, 7421–7428.
Department teachers in Lancashire are ill-educated, 7432.
Objection to teachers who have passed but one examination; they should be trained in science colleges, 7435.

Seminaria.
In Germany; might be introduced here with benefit, 7389.

Stewart, Professor Balfour.
Physical laboratory under, in Owens College, 7366.
On physical laboratories, 7418.

Training Colleges.
Proper education in, of science teachers, will repay Government cost, 7435.

Universities (Continental). See *Science Schools (Continental).*

Whitworth Scholarships.
Artizans who have gained them in Owens College; half are adjudged to artizans and half to students, 7409, 7410.

Wurtz, M.
His report on German laboratories, 7385.

Zurich.
Science instruction in, 7384, 7389.

Zwickau.
Account of Zwickau Free Mining School, 7389.

ANALYSES OF EVIDENCE

RESPECTING THE

SCOTCH AND IRISH UNIVERSITIES.

University of Edinburgh.

TURNER, PROFESSOR WILLIAM, M.B. (Index of his Evidence.)

Agriculture.
Endowment by special bequest of chair of agriculture in Edinburgh University, 9276.

Accommodation for Science Purposes.
Buildings at Edinburgh University; want of class rooms, laboratory, &c.; proposal to remove medical school, 9278–9288.
Government aid essential for extension of buildings, &c. at Edinburgh University, 9294–9313, 9388.

Anatomy.
100 lectures, and practical instruction, given annually to medical students at Edinburgh University, 9264.
Professor of anatomy in Edinburgh University is the only professor without a salary, 9272.
Want of accommodation for teaching anatomy in Edinburgh University; extended instruction desirable, 9284, 9287, 9312.
Professor of natural history in Edinburgh University teaches zoology from a comparative anatomy point of view, 9323–9328.
Anatomical museum at Edinburgh University; open to students; extensively used by professors, 9318–9324.

Apparatus for Science Purposes.
Diagrams, preparations, &c. used for instructing medical students at Edinburgh University, 9264.
Government grant essential for apparatus, and research, at Edinburgh University, 9301, 9312, 9334.

Arts.
Fellowships, &c. at Edinburgh University are chiefly associated with faculties of art and theology, 9276.

Assistant Professors, Demonstrators, &c.
Assistant professors at Edinburgh University (mostly graduates) are appointed partly by University, partly by professors, 9265–9268, 9313–9317.
Increased endowments for payment of assistants wanted at Edinburgh University, 9301–9312, 9396.
Importance to professors of having highly skilled assistants, 9337.
Assistants to professors consider their duty as training for professorships, 9338.

Botany.
Lectures and practical demonstrations in botany given to medical students of Edinburgh University, 9264.
Extension of instruction in botany desirable at Edinburgh University, 9312.

Bursaries.
Appropriation of funds to bursaries in Edinburgh University, 9269.

Chairs. See *Professorships.*

Chemistry.
Chemistry is one of the general sciences taught to medical students at Edinburgh University, 9264.
Extension of instruction in chemistry desirable at Edinburgh University, 9284, 9312.

Degrees.
Examinations for Edinburgh University degree in medicine are in three stages; all are written, oral, and practical, 9291, 9329–9333.
Degrees of Bachelor of Medicine, Master of Surgery, and Doctor of Medicine are conferred by Edinburgh University, 9291–9294.

TURNER, Prof.—cont.
B.A. degree from another university stands in place of preliminary examination at Edinburgh University, 9293.
Degree in science, as well as in medicine, is given by Edinburgh University, 9294.

Edinburgh.
Edinburgh has been a great training school for professors, 9314.

Edinburgh University.
Promotion of science at Edinburgh University, 9262–9340, 9386–9396.
See *Professors, Students, &c.*

Endowments.
Special bequests at Edinburgh University for chairs of agriculture, natural history, sanscrit, music, and engineering, 9276.
See *Income and Expenditure.*

Engineering.
Endowment by special bequest of chair of engineering in Edinburgh University, 9276.

Examinations.
Examinations for degree in medicine at Edinburgh University are written, oral, and practical; students pass a preliminary examination, 9264, 9291–9294, 9329–9333.
In Scottish universities, no examination is required previously to matriculation, 9290.
In professional examinations for Edinburgh B.M. degree a thesis is required, 9291.
Examinations of first year in Edinburgh University are open to other than medical students, 9294.

Exhibitions. See *Fellowships, &c.*

Fees. See *Income and Expenditure.*

Fellowships.
Appropriation of funds to fellowships, scholarships, and exhibitions, at Edinburgh University, 9269, 9276.
Bursaries, scholarships, and fellowships at Edinburgh University are chiefly for arts and theology; for medicine, one; natural science, three, 9276.
List of prizes or scholarships for science and medicine at Edinburgh University, 9309.

Government.
Grants of Government towards buildings, &c. of Edinburgh University; grants for extension, &c. wanted, 9278, 9313, 9389–9392.
See *Parliament.*

Greek.
Greek is required for degree of Doctor of Medicine of Edinburgh University, 9292.

Income and Expenditure.
Funds of Edinburgh University; capital, 144,951*l.*; application of funds to chairs, prizes, salaries, &c., 9265–9277, 9290, 9302, 9393–9395.
Contributions and Government grants to Edinburgh University, 9272–9278, 9294–9313, 9386–9396.
Desirable that Edinburgh University should be able to hold out pecuniary inducements to students, 9309.
Edinburgh University is miserably poor, 9387.

Laboratories.
Laboratories at Edinburgh University; materia medica laboratory is too small, 9264, 9282, 9284.

TURNER, Prof.—cont.

Lectures.
Lectures on chemistry, botany, &c. given to Edinburgh University medical students, 9264.
18 lecture-rooms for 40 courses of lectures at Edinburgh University; great want of accommodation, 9284.

Library.
1,584*l.* spent annually on library at Edinburgh University; a magnificent hall; more room wanted, 9270, 9278, 9281.

Literature.
Examination in English, Latin, &c. passed by all Edinburgh University medical students, 9292.

Materia Medica.
Materia medica instruction at Edinburgh University; laboratory wanted, 9264, 9284.

Matriculation.
Different meaning of "matriculation" in England and Scotland, 9290.
No entrance examination previously to matriculation in Scottish universities, 9290.

Medicine.
Department of medicine at Edinburgh University comprises general sciences, sciences appertaining to medicine, and special medical subjects; 722 students, 9264, 9287–9289.
Practice of medicine, medical psychology, surgery, midwifery, medical jurisprudence, clinical surgery, &c. are taught at Edinburgh University, 9264, 9281.
Amount and distribution of funds appropriated to medicine at Edinburgh University, 9269–9277.
Of scholarships, &c. at Edinburgh University, there is only one with medicine, 9276.
Chair of Institutes of Medicine, and chair of Practice of Physic, in Edinburgh University; want more accommodation, 9281, 9284.
Proposal to transplant medical school of Edinburgh University to a new site, 9284–9286.
Degrees of Bachelor of Medicine, Master of Surgery, and Doctor of Medicine, are conferred by Edinburgh University, 9291–9294.
Medical degree examinations at Edinburgh University are conducted by medical professors and non-professorial examiners, 9291–9294, 9329–9333.
List of prizes for medical students at Edinburgh University, 9309.

Microscopy.
Microscopic demonstrations on vegetable tissues, &c. given at Edinburgh University, 9264.

Midwifery.
Midwifery instruction given at Edinburgh University, 9264.

Museums.
Excellent museum of materia medica at Edinburgh University, 9264, 9282.
Anatomical and botanical museums at Edinburgh University; the former open to students, and extensively used by professors, 9270, 9318–9324.

Museum of Science and Art (Edinburgh).
Museum of Science and Art has damaged many rooms in Edinburgh University by cutting off the light, 9284.

Music.
Bequest of General Reid for chair of music at Edinburgh University, and concert, 9276, 9279, 9281.

Natural History.
Endowment by special bequest of chair of natural history in Edinburgh University, 9276.
More accommodation and extended instruction in natural history desirable at Edinburgh University, 9284, 9312. See *Zoology.*

Natural Philosophy.
Chair of natural philosophy in Edinburgh University was founded in 1708, 9281.

Original Research.
Want of accommodation and funds for original research at Edinburgh University, 9307–9309, 9334.
Professors should have time for research; Edinburgh professors engage in research as far as possible, 9335, 9336.

Pathology.
Practical instruction in pathology given at Edinburgh University; more accommodation wanted, 9264, 9281, 9284.

TURNER, Prof.—cont.

Pharmacy.
Want of laboratory for teaching pharmacy at Edinburgh University, 9284.

Physiology.
Lectures and practical instruction in physiology at Edinburgh University; extension of instruction desirable, 9264, 9312.

Practical Instruction.
Practical demonstrations in anatomy, botany, &c. given at Edinburgh University, 9264.
Practical knowledge must be shown in examinations for degree in medicine at Edinburgh University, 9291.

Prizes. See *Fellowships, &c.*

Professors.
Professors and assistants at Edinburgh University; latter appointed partly by University and partly by professors, 9264–9277, 9391, 9392.
Allowances of Edinburgh University for professors assistants are miserably inadequate, 9301–9304.
Edinburgh has been a great training school for professors, 9314.
Importance to professors of highly-trained assistants; these latter work for professorships, 9337, 9338.
Professors should have time for research, 9335, 9336.

Professorships.
Edinburgh University professorships; their antiquity, &c., 9269–9281.
Numerous professorships in England, the colonies, &c. filled by Edinburgh graduates, 9314.

Reid, General.
Bequest of General Reid for chair of music at Edinburgh University, and concert, 9276, 9279, 9281.

Religion.
Scholarships, &c. at Edinburgh University are chiefly associated with faculties of arts and theology, 9276.

Salaries. See *Income and Expenditure.*

Sanscrit.
Endowment by special bequest of chair of Sanscrit in Edinburgh University, 9276.

Schools.
Teachers of schools might be instructed in science by Edinburgh University if it had means, 9339, 9340.

Scholarships. See *Fellowships, &c.*

Science.
Of scholarships, &c. at Edinburgh University, there is one with medicine, and three with natural science, 9276.
Degree in science given by Edinburgh University, 9294.
List of science prizes at Edinburgh University, 9309.
School teachers might be instructed in science by Edinburgh University if it had means, 9339, 9340.

Scottish University Commission.
Important reforms introduced into Edinburgh University by Scottish University Commission, 9265–9277, 9310.

Students.
Lectures and practical demonstrations in chemistry, botany, &c. given to Edinburgh University medical students, 9264.
Matriculation, graduation, fees, &c. of Edinburgh University students, 9269–9277, 9290, 9393–9395.
Extension of Edinburgh University required on account of great increase of students, 9284, 9287.
Examinations of Edinburgh University students; medical students must pass preliminary examination, 9291–9294.
Edinburgh University should be able to hold out pecuniary inducements to students, 9309.
Assistants to professors at Edinburgh University are mostly young graduates, 9313–9317.

Surgery.
Lectures and practical instruction in surgery given at Edinburgh University; more accommodation wanted, 9264, 9281, 9284.

Teachers.
With increased means, Edinburgh University might instruct school teachers in science, 9339, 9340.

Zoology.
Zoological instruction at Edinburgh University; it is now given from a comparative anatomy point of view, 9264, 9324.

BROWN, Professor ALEX. CRUM. (Index of his Evidence.)

Accommodation for Science Purposes.
Bad accommodation for chemical instruction at Edinburgh University, 9355–9357, 9363–9369.
In proposed chemical laboratory at Edinburgh University, 5 feet by 6 of space is allotted to each worker, 9378.

Age of Students.
Students up to 25 years of age can compete for Edinburgh University Hope Scholarships, 9385.

Agriculture.
Special lectures on agricultural chemistry should be given at Edinburgh University, 9373.

Apparatus for Science Purposes.
Chemical apparatus at Edinburgh University is mostly inapplicable; specimens are obtainable from Museum of Science and Art, &c., 9349–9354.
Insufficient grant for lecture apparatus at Edinburgh University, 9360–9363.
Apparatus for original research should be provided at Edinburgh University, 9371, 9372.

Assistant Professors, Demonstrators, &c.
Two assistants to chemical professor provided by Edinburgh University; professor provides others at his own cost, 9347, 9348, 9358–9360.

Botany.
Botany is one subject of examination for Edinburgh University degrees, 9379.

Chemistry.
Chemical instruction at Edinburgh University; inefficient accommodation and apparatus; comprises elementary lectures, and practical teaching; there is also tutorial instruction, 9341–9363.
Lectures on the application of chemistry should be given at Edinburgh University, 9373, 9374.
Chemistry is a subject of examination for Edinburgh degrees in science and medicine, 9379–9382.

Degrees.
Every candidate for a degree in science of Edinburgh University must pass first B.Sc. examination, 9382.
A B.Sc. may be a candidate for D.Sc. degree, and be examined in any one of a number of subjects, 9382.
Degrees in science are a recent institution in Edinburgh University, 9383, 9384.
See *Examinations.*

Edinburgh Museum of Science and Art.
Specimens in Edinburgh Museum of Science and Art are available for lectures in University, 9349–9354.

Edinburgh University.
Promotion of science at Edinburgh University, 9341–9395.
See *Professors, Students, &c.*

Engineering.
Engineering department at Edinburgh University should comprise lectures on applications of chemistry, &c., 9373, 9374.

Examinations.
Examinations for degrees in medicine at Edinburgh University comprise chemistry, botany, and zoology, and are written, practical, and oral, 9379.
Professor and one non-professorial examiner conduct chemical examinations at Edinburgh University, 9380.
Increased number of non-professorial examiners desired by Edinburgh University professors, 9380, 9381.
Examinations for Hope Chemistry Scholarship at Edinburgh University; students up to 25 years of age can compete, 9385.
See *Degrees.*

Hope, Professor.
Hope chemistry prize at University of Edinburgh; converted into a scholarship, 9385.

Income and Expenditure.
Assistants to chemical professor at Edinburgh University receive 200*l.* from University, and rest from professor, 9358–9360.
100*l.* a year allowed by Edinburgh University for chemical apparatus, &c.; more necessary, 9361, 9363.
Edinburgh University should have funds for promotion of original research, 9367–9377.
Lecturers should not depend wholly on fees, or have to defray class expenses, 9377.
1,000*l.* bequeathed to Edinburgh University by Professor Hope for chemical prize, 9385.
Additional chairs, although founded by private and Government money, make additional demand on university funds, 9395.

BROWN, Prof.—cont.

Laboratories.
Laboratories at Edinburgh University; chemical laboratory unsuitable, 9342–9344, 9356, 9363–9366.
In proposed new buildings at Edinburgh University space for 40 chemical laboratory students is projected, 9364, 9378.
Holder of Hope Chemistry Prize at Edinburgh University must work a year in a laboratory, 9385.

Lectures and Lecturers.
Lectures at Edinburgh University; lectures on applications of science desirable, 9342, 9349, 9354, 9373, 9374.
Lecturers should not depend on fees, or defray class expenses, 9377.

Medicine.
Chemical instruction of medical students at Edinburgh University; increasing number of students; inadequate space, 9342–9346, 9363–9365.
Professor of medical jurisprudence at Edinburgh University has a laboratory, 9366.

Metallurgy.
Special lectures on metallurgy should be given at Edinburgh University, 9373.

Museum of Science and Art (Edinburgh). See *Edinburgh Museum, &c.*

Original Research.
For original research at Edinburgh University space and funds are wanted, 9367–9377.

Physiology.
Special lectures on physiological chemistry should be given at Edinburgh University, 9373.

Practical Instruction.
Practical instruction in chemistry, in classes and laboratory, is given at Edinburgh University; accommodation inadequate, 9342–9344, 9356.
Practical knowledge is required for degrees at Edinburgh University, 9379.

Professors.
Professor of chemistry at Edinburgh University; is allowed two assistants; has bad accommodation, &c., 9341–9357.
Lecturers, under professors, would improve teaching power of Edinburgh University, 9373, 9374.

Professorships.
Additional professorships, although founded by private and Government aid, increase demand on university funds, 9395.

Scholarship.
Hope Chemistry Prize at Edinburgh University is converted into a biennial scholarship, 9385.

Science.
Promotion of science at Edinburgh University, 9341–9395.

Students.
Chemical students of Edinburgh University; great increase in their number, 9342–9346, 9356.
Large amount of space required by students of chemistry; inadequate accommodation at Edinburgh University, 9357, 9363–9365.
Funds should be provided at Edinburgh University to employ advanced students in research, 9367–9377.
Candidates for degrees in medicine, &c. at Edinburgh University, 9379–9385.

Tutorial Instruction.
Tutorial classes in chemistry are held at Edinburgh University, 9343.

Zoology.
Zoology is one subject of examination for Edinburgh University degrees, 9379.

TAIT, Professor PETER GUTHRIE. (Index of his Evidence.)

Accommodation for Science Purposes.
Bad accommodation for natural philosophy instruction at Edinburgh University, 9408, 9416–9419.

Anatomy.
Removal of anatomy department at Edinburgh University desirable for accommodation of natural philosophy, 9416–9419.

Artizans.
Universities should give scientific instruction to artizans, 9434.

Tait, Prof.—cont.

Assistant Professors, Demonstrators, &c.
Want of assistants in natural philosophy department at Edinburgh University, 9420–9424, 9437–9441.
Natural philosophy laboratory work should be conducted by assistant professors; one to ten students, 9455, 9456.

Chemistry.
Removal of chemical department at Edinburgh University desirable for natural philosophy extension, 9416–9419.

Degrees.
Honorary degrees only should be given by universities, except where they have taught the candidates, 9458.
To teach, not to give degrees, is the primary object of a University, 9458.

Edinburgh University.
Natural philosophy instruction at Edinburgh University, 9397–9462.
See *Professors, Students, &c.*

Engineering.
Some technical work might be done in engineering department at Edinburgh University; it is best learnt in a workshop or engineer's office, 9429–9431.
Advanced teaching of natural philosophy at Edinburgh University is adapted for diploma of engineering, 9450.

Examinations.
Frequent examinations in natural philosophy at Edinburgh University, 9402–9404.
Importance of frequent examinations in connexion with teaching, 9402.
Slight examinations in natural philosophy for medical students at Edinburgh University, 9461.

Income and Expenditure.
Poverty of Edinburgh University; want of funds for natural philosophy instruction, &c., 9410–9415, 9426, 9442.
Matriculation and graduation fees the only resources for aiding Edinburgh University professors, 9413–9415.
Funds wanted for removal of Edinburgh University departments of chemistry and anatomy, and extension of natural philosophy department, 9416–9418.
Universities should have funds to enable them to aid investigators, 9435, 9436.
520*l.* per annum additional required for extension of physical laboratory instruction at Edinburgh University, 9443.
Remuneration to induce students to become assistants should be offered by Edinburgh University, 9456, 9457.

Laboratories.
Physical laboratory at Edinburgh University; inadequate accommodation, 9404–9419, 9454.
For physical laboratory teaching at Edinburgh University, two additional assistants should be appointed, and pay of present assistants doubled, 9413, 9414.
Laboratory work should be conducted by assistants, but be looked after by professor; one assistant might superintend 10 students, 9455, 9456.

Lectures.
100 lectures on natural philosophy to junior students, 60 to advanced students, besides tutorial instruction, given at Edinburgh University, 9400, 9401.

Light.
Light not included, for want of time, in natural philosophy course at Edinburgh University, 9450.

Mathematics.
Applications of higher mathematics to physical science explained in natural philosophy courses at Edinburgh University, 9400.
Want of preparation in mathematics shown by Edinburgh University natural philosophy students, 9446–9448.
Advanced teaching of natural philosophy at Edinburgh University is adapted for honours in mathematics, 9450.

Matriculation.
Professors of Edinburgh University only casually assisted by matriculation and graduation fees, 9413–9416.

Medicine.
Natural philosophy course at Edinburgh University is attended by a few medical students; they have only to pass slight examination, 9461.

Natural Philosophy.
Instruction in natural philosophy at Edinburgh University; frequent examinations, 9397–9462.

Tait, Prof.—*Natural Philosophy.*—cont.
Impediments to teaching of natural philosophy at Edinburgh University through want of funds, 9413–9124, 9442.
Edinburgh University should teach principles of natural philosophy, not technical work, 9428–9431.
Natural philosophy departments in universities should each be under control of one professor, with assistants, 9437–9441.
Want of mathematics shown by students of natural philosophy at Edinburgh University, 9446–9448.
Natural philosophy advanced instruction at Edinburgh University is adapted to honours in mathematics or diploma of engineering, 9450.
One professor, with assistance, could teach principles of natural philosophy and mathematical physics; two chairs might create difficulties, 9451–9453.
Theological students of natural philosophy at Edinburgh University, 9459, 9460.
Medical students at Edinburgh University have only slight examinations in natural philosophy; a few attend the course, 9461.

Original Research.
Professor of natural philosophy at Edinburgh University has no time for original research, 9425.
Edinburgh University should teach the mode of conducting original research, 9428.
Universities should be able to offer facilities in their laboratories for original research, 9435, 9436.

Professors.
Difficulty of professors at Edinburgh University through poverty of University, &c., 9413, 9442–9448.
Professor of natural philosophy at Edinburgh University has no time for research, 9425.
One professor, with skilled assistants, should control a natural philosophy department, 9437, 9441.
Principles of natural philosophy and mathematical physics should be taught by the same professor, 9451–9453.

Professorships.
Two chairs of natural philosophy at Edinburgh University might cause difficulties, 9451–9453.

Religion.
Many natural philosophy students at Edinburgh University are intended for the ministry, 9459.
Theological students of Presbyterian bodies have to attend instruction in natural philosophy, 9460.

Schools.
Technical schools could not teach both principles and applications of science, 9431.
Teachers of schools ought to be instructed by a teaching university, 9432, 9433.

Science.
Natural philosophy instruction at Edinburgh University, 9397–9462.
Principles of science, not technical applications, should be taught in schools, &c., 9428–9431.
Scientific instruction should be given in universities to teachers of schools, artizans, &c., 9432–9434.
Science could not be better advanced than by universities offering facilities to original investigators, 9435.
For one man who can teach the principles of a science, hundreds can teach details, 9440.

Scottish Universities. See *Universities.*

Students.
Natural philosophy students in Edinburgh University; 175 in junior, five or six in advanced class; badly prepared in mathematics; some intended for the ministry, 9400–9412, 9446–9448, 9459–9461.
10 or 12 students only (elementary and advanced) can work in Edinburgh University physical laboratory, 9407–9412, 9454.
University students should have instruction in principles of science, not technical applications, 9428–9431.
Students reading for honours in mathematics or diploma of engineering could attend advanced natural philosophy instruction at Edinburgh University, 9450.
Remuneration to induce students to remain as assistants to professors should be offered by Edinburgh University, 9456, 9457.
A few medical students attend Edinburgh University natural philosophy course; they only pass a slight examination, 9461.

Teachers.
Teachers of schools ought to be instructed by a teaching university, 9432, 9433.

Technical Instruction.
Objection to technical instruction at Edinburgh University; workshop or engineer's office preferable, 9428–9431.

TAIT, Prof.—cont.

Telegraphy.
Technical instruction in telegraphy might be given at Edinburgh University, 9429.

Tutorial Instruction.
Tutorial lectures on natural philosophy given at Edinburgh University, 9400, 9401.

Universities.
Natural philosophy instruction, &c. at Edinburgh University, 9397–9462.
Universities ought to be the instructors of teachers in schools, artizans, &c., 9432 9434.
Universities should be able to offer facilities to original investigators, 9435, 9436.
Honorary degrees only should be conferred by universities, except where they have taught the candidates, 9458.
The primary object of a university is not to give degrees, but to teach, 9458.

Workshops.
Technical instruction best given in workshops, 9429–9431.

GEIKIE, PROFESSOR ARCHIBALD, F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
Great want of accommodation in department of geology and mineralogy at Edinburgh University, 9466 9470, 9497–9501.
One hall of new buildings of Edinburgh Science and Art Museum should be devoted to geological specimens, 9483–9487.

Anatomy.
Desirability of transferring Edinburgh University anatomical department to new buildings, 9500, 9501.

Apparatus for Science Purposes.
Diagrams, models, &c. wanted at Edinburgh University for geological instruction; specimens are borrowed from Museum of Science and Art, 9467 9481, 9491.

Architects.
Practical instruction in geology and mineralogy at Edinburgh University desirable for architects, 9470.

Chemistry.
Desirability of transferring Edinburgh University chemical department to new buildings, 9500, 9501.

Crown, The.
Edinburgh University natural history specimens handed over to the Crown; a mistake, 9471–9482.

Degrees.
Geological course at Edinburgh University not essential for degrees; but attendance upon it qualifies for degree of doctor of science, 9495, 9496.
Attendance on zoological course at Edinburgh University is necessary for medical degree, 9196.

Edinburgh.
Advantage of Edinburgh as a locality in which to teach geological science, 9502.

Edinburgh Museum of Science and Art.
Museum of Science and Art, Edinburgh; founded to illustrate industrial resources of Scotland; only partially carried out; one hall of new buildings should be appropriated to this, 9471 9487.

Edinburgh University
Geological instruction at Edinburgh University, 9463–9503
See *Professors, Students, &c.*

Endowments. See *Income and Expenditure.*

Engineers.
Practical instruction in geology and mineralogy at Edinburgh University desirable for engineers, 9470.

Geological Survey (England and Wales).
Geological specimens are not now sent from Scottish Survey to English Survey, 9490
Rock specimens in Jermyn Street Museum are arranged by Director, and fossils by Palæontologist, 9490.

Geological Survey (Scotland).
Large collections of rocks, fossils, &c. made by Scottish Geological Survey; a few exhibited in Museum of Science and Art; the rest are in cellars, 9483 9487.

Geology.
Geological science at Edinburgh University, 9463 9503.
Chair of geology and mineralogy at Edinburgh University, founded by Sir R. Murchison, aided by Parliament, 9461.

GEIKIE, Prof.—*Geology.*—cont.
Inadequate accommodation at Edinburgh University for teaching geology and mineralogy; rooms with lathes, microscopes, blowpipes, &c. essential, 9466–9470, 9500, 9501.
Professor of geology and mineralogy at Edinburgh University should control specimens in Museum of Science and Art, 9471–9482.
Scottish Geological Survey; its collections should be in Museum of Science and Art; it might supply museums with specimens, 9483 9488.
Geology course at Edinburgh University not necessary for a degree; attendance qualifies for D. Sc., 9495–9496.
Advantage of Edinburgh as a locality in which to teach geological science, 9502.
Practical field instruction given by Edinburgh University professor of geology, 9502.
Teachers of schools might attend geology course at Edinburgh University, 9502.

Grants for Science Purposes.
Government annual grant of 200*l.* for chair of geology and mineralogy at Edinburgh University, 9464.

Income and Expenditure.
6,000*l.* from Sir R. Murchison, and 200*l.* per annum from Government, contributed to found chair of geology and mineralogy at Edinburgh University, 9464, 9465.

Lectures
Want of accommodation for geological lecture illustrations at Edinburgh University, 9466–9470.

Medicine.
Medical students attend geology course at Edinburgh University, 9494.
Attendance on zoological course at Edinburgh University is essential for medical degree, 9496.

Mineralogy. See under *Geology.*

Mining.
Practical instruction in geology and mineralogy at Edinburgh University would be serviceable to miners, 9470.
Mining engineers attend geological course at Edinburgh University, 9493.

Murchison, Sir R.
Sir R. Murchison contributed 6,000*l.* towards foundation of chair of geology and mineralogy at Edinburgh University, 9464, 9465.

Museum of Practical Geology. See *Geological Survey (England and Wales).*

Museums.
Scottish museums might be furnished with specimens by Geological Survey, if it had more collectors, 9487, 9488.

Natural History.
Natural history chair at Edinburgh University till lately included geology and mineralogy, 9461.
Professor of natural history in Edinburgh University is Regius Keeper of natural history in Museum of Science and Art; he has not complete control, as he should have, over specimens, 9471 9482.
See *Geology.*

Practical Instruction.
Practical instruction in geology and mineralogy, by aid of blowpipes, microscopes, &c., ought to be given at Edinburgh University, professor gives field instruction, 9466 9470, 9491, 9502.
Advantage of Edinburgh as a locality in which to study practical geology, 9502.

Professors
Professor of geology and mineralogy at Edinburgh University has bad accommodation, 9161 9182, 9502.
Edinburgh University professor of natural history should control natural history specimens in Science and Art Museum, of which he is Regius Keeper, 9471–9482.

Professorships.
Geology and mineralogy lately included in natural history chair at Edinburgh University; now separated, 9464.
New professorship of geology and mineralogy at Edinburgh University founded by Sir R. Murchison, aided by Parliament, 9461, 9465.
Chair of geology at Edinburgh University should embrace not merely lectures but practical instruction, 9469.

Schools.
School teachers might attend the geology course at Edinburgh University 9502.

GEIKIE, Prof.—cont.
Science.
Geological science at Edinburgh University, 9463–9503.
Scotland. See *Geological Survey (Scotland).*
Students.
Students of geology at Edinburgh University; comprise mining and medical students, &c., 9492–9494.
Teachers.
Teachers of schools might receive instruction in geology at Edinburgh University, 9502.
Zoology.
Zoology now separated from geology in natural history chair at Edinburgh University, 9464.
Attendance on zoological course at Edinburgh University is essential for medical degree, 9496.

University of Glasgow.

THOMSON, SIR WILLIAM. (Index of his Evidence.)
Accommodation for Science Purposes.
New buildings at Glasgow University for extension of science teaching, 2653–2655.
Age of Science Students.
Science teaching might commence with pupils of 12 years; but general scientific knowledge could be imparted earlier, 2781, 2782.
Andersonian University.
Science classes for artizans at Andersonian University; they are not technical; would not be attended if they were, 2802–2806.
Apparatus for Science Purposes.
Government allowance for lecture apparatus in Glasgow University, 2765–2768, 2772.
Arnott, Dr. Neil.
His donations for promotion of physical science, 2661.
Artizans.
No instruction given to artizans in Glasgow University; desirable, but staff insufficient, 2726–2731.
Desirability of establishing science schools for artizans, 2791–2795.
Artizans' science classes at the Andersonian University, 2802–2806.
Workmen do not attend classes to learn their trades, but to understand the principles of science, 2804–2806.
Assistant Professors. .
Assistants to professors are essential for proper science teaching; insufficient provision for this at present, 2828–2832.
See *Professors.*
Chairs of Science. See *Professorships.*
Chemical Laboratories.
For testing articles for sale, should be founded in every chief town, 2716.
See *Laboratories.*
Chemistry.
Objection to teaching technical chemistry; principles all important, 2793, 2844–2849.
Children.
Scientific instruction might be commenced with children of 12 to 14 years of age, 2781, 2782.
Classics. See *Literature.*
Contributions for Science Purposes.
Donations by Dr. Neil Arnott, and witness, for promoting physical science, 2661, 2662.
Approval of a Government grant being offered on condition that a like sum be voluntarily raised; success of system in Glasgow, 2688–2692, 2783, 2784.
Cost of Scientific Instruction.
Expenses of Glasgow University laboratory, 2768.
See *Salaries.*
Council of Scientific Advice.
Advantage to Government of a council constituted like the Government Grant Committee of the Royal Society; it should be non-political, 2693–2697, 2723–2725, 2867, 2868.
Degrees.
Glasgow University degrees; no special degree in science; degree of doctor of science would be desirable; diploma of engineering proposed to be constituted into a degree, 2682, 2837–2841.
Objection to candidates for degrees having to perform a piece of work, 2833–2836.
Less classics, and more science, desirable for master of arts' degree, 2840, 2841.
Edinburgh University.
Lectures to ladies at, 2726.
Dissatisfaction with its site and buildings, 2871.
Education.
The education of a pupil whose profession is foreseen may be modified, 2814–2817.

THOMSON, Sir W.—cont.
Elementary Schools.
The teaching of science in national schools urged by Glasgow University, 2686.
Endowments.
Professorships should have endowment, in addition to fees, &c., 2676, 2677, 2733–2741.
Engineering.
Professor Rankine's engineering class at Glasgow; students before obtaining a diploma must have attended classes in mathematics, chemistry, &c., 2773–2776.
Objection to technical instruction, except with regard to engineering, 2793–2820, 2842–2859.
Diploma of engineering in Glasgow University proposed to be constituted into a degree, 2839.
Evening Classes.
Desirability of having evening instruction for artizans, &c. at Glasgow University, 2726–2731.
Examinations.
Daily and weekly examinations of students in Glasgow University; examinations for degrees, 2678–2682, 2865, 2866.
Vivâ voce examinations more important in teaching than in testing, 2683.
Objection to preliminary examination for students entering a university, 2685, 2760.
Periodical examinations, at short intervals, desirable in public schools, 2780.
Examination for degrees; present system more effective than prescribing of theses, 2836, 2840, 2841.
Faculties.
The faculties of medicine and arts comprise nearly all of what is called science, 2656.
Fees.
Professorships should have endowments, in addition to fees, &c., 2676, 2677, 2733–2741.
Comparison of fees with endowments, in Glasgow University, 2788–2790.
Fellowships. See *Scholarships, Fellowships, &c.*
Geology.
Special chairs for geology desirable in Scotland, 2741–2743.
German Universities.
Objection to candidates for degrees in, having to perform a piece of work, 2833–2836.
Glasgow University.
Promotion of scientific instruction in the University; new buildings for science purposes, 2653–2655.
Faculties of theology, law, arts, and medicine, in the University; the two latter comprising science, 2656.
University professors, their fees, salaries, residences, pensions, &c. Assistant professors lately appointed; number inadequate; they work under the professors, 2658–2660, 2681, 2732–2759, 2769–2772, 2788–2790, 2863.
Scholarships, &c. for promotion of science in the University, 2661–2664.
Students at Glasgow; combine literary and scientific studies; they enter University not well prepared, 2666, 2684, 2685.
Examinations at Glasgow; none compulsory, except for degrees; teachers examine daily or weekly, 2678, 2679.
University degrees; professors' reports are taken, but examination is conducted independently; a degree of doctor of science would be advantageous, 2682, 2837–2841.
Interest taken by University in the Scotch Education Bill, 2686.
Government grant and private contributions for new buildings of University, 2688–2692, 2783–2787.
Laboratories in University; no applicant refused; investigations, expenses, &c., 2698–2712, 2760–2768.
No instruction given to artizans or ladies in the University; desirable there should be, 2726–2732, 2791, 2792.

THOMSON, Sir W.—*Glasgow University*—cont.
- Professor Rankine's engineering class in the university, 2773–2776.
- Lectureship in university for teaching application of Smith's magnetic principles to adjustment of compass, 2815.
- The system of teaching in the university is, that the professor has the whole charge, and the tutorial staff work under him, 2865.

Government
- Demand by Glasgow University for higher teaching in Government national schools, 2686.
- Liberality of late Government to Glasgow University, 2688–2692.
- Advantage to Government of a council of scientific advice, 2695–2697.

Government Grant Committee (Royal Society).
- A similar council would be the best scientific adviser Government could have, 2693–2697, 2723–2725.
- Committee might be improved by more publicity, addition of delegates from universities, &c., 2822–2828.

Government Grants in aid of Science.
- Approval of Government offering money for science purposes on condition of a like sum being voluntarily raised; impetus given to private subscription thereby, 2688, 2689, 2783, 2784.
- Public money should be granted for chemical and physical laboratories, 2716–2725.
- A grant should be made to Owens College, 2785–2787
- Allowance to Glasgow University laboratory, 2765–2768, 2772.
- Large grants made to universities in Scotland, 2869.
  - See *Salaries.*

Joule, Dr.
- His opinion quoted, that a professor should be largely occupied in original research, 2671.

Laboratories.
- Glasgow University laboratory; originated with volunteer students; its effect is to train men to original inquiries; might be made available for artizans; open to anyone, 2698–2712, 2730, 2760–2768.
- Approval of proposed connexion of laboratories with universities, &c., 2713–2715.
- Desirability of founding chemical and physical laboratories; should be aided by public money, 2716–2725.
- Laboratories essential for all scientific teaching; insufficiently provided at present, 2828–2832.

Ladies.
- Instruction to ladies at Edinburgh University; none at Glasgow University; staff insufficient; ladies' laboratory not wanted, 2726, 2730.

Lectures.
- In Glasgow University, the lectures are regulated by the rules of the senate, 2751–2754.

Literature.
- Advantage of combination of literary and scientific studies, 2665–2668.
- Classics should be required for master of arts' degrees; but a less amount and more science desirable, 2840, 2841.

Manufacture
- Objection to teaching of science applied to manufacture in science schools, 2793–2820, 2842–2859.

Medicine.
- The technical part of medicine must be learned in the hospitals, 2807, 2808.

Metallurgy.
- Objection to technical metallurgy being taught in schools of science, 2796–2806.

Military Colleges.
- Objection to special military colleges, 2819.

Mining
- Technical instruction in mining less important than instruction in geology, heat, &c., 2816, 2817, 2850–2852.

Natural History.
- The natural history chair (which includes geology and zoology) in Scotland should be divided, 2741–2743.

Navigation.
- Objection to technical navigation being taught in schools of science, 2801–2820, 2853–2855.

Original Research.
- Original research should be combined with teaching, 2669, 2670, 2671, 2860–2862.
- Laboratory work effective in training men to original research, 2698–2715.
- Establishment of chemical and physical laboratories the best means of promoting original research, 2716–2725.

THOMSON, Sir W.—cont.
- The chief source of discovery has been the contact of students with persons engaged in scientific research, 2860–2862.

Owens College.
- Professorships; college entitled to Government support; refusal of grant by Government, 2671–2675, 2785–2787, 2869.

Practical Instruction.
- Practical work in Glasgow University laboratory, 2698–2713.

Professors.
- Glasgow University professors; assistants; nomination and election; salaries; residences; superannuation, 2656–2660, 2679–2681, 2726–2759, 2863, 2864.
- Professors should be also prosecutors of original research, 2669–2674, 2860–2862.
- Necessity of professors and tutors working together under one head, 2864.

Professorships.
- Glasgow University professorships, 2656–2660, 2733–2759.
- Professorships should have endowments in addition to fees, 2676, 2677, 2733–2741.
- The Scottish natural history professorship should be divided, 2741–2743.
- Technical science professorships desirable only in certain cases, 2818, 2842–2857.

Regius Professorships.
- None now in Glasgow University, 2744–2752.

Salaries.
- Professors' and assistants' salaries in Glasgow University, 2659, 2660, 2733–2743, 2769–2772.

Scholarships, Fellowships, &c.
- Arnott scholarships, &c.; Eglinton and Breadalbane fellowships, in Glasgow University, 2661–2664.

Schools.
- Periodical examinations, at short intervals, desirable in public schools, 2780.

Science.
- Increased facilities for teaching science at Glasgow University, 2653–2655.
- Donations by Dr. Neil Arnott, and witness, for promotion of physical science, 2661.
- Advantage of combination of literary and scientific studies, 2665–2668.
- Teaching of science in national schools urged by University of Glasgow, 2686.
- Approval of aid to science by Government offering a sum on condition of a similar sum being voluntarily raised, 2688–2692.
- Desirability of having a council of scientific advice, 2693–2697, 2723–2725, 2867, 2868.
- Advantage of laboratory work; approval of proposed connexion of laboratories with universities, &c., 2698–2725.
- Scientific instruction should be given to artizans and to ladies, 2726–2731.
- Geology and zoology should be independent chairs, 2741–2743.
- Science teaching might commence with children of 12 years; but a general knowledge of science may be imparted earlier, 2781, 2782.
- Objection to technical instruction in science schools, &c., 2793–2820, 2842–2859.
- The teaching of science must comprise lectures, tutorial work, and laboratory work; the two latter are insufficiently provided for, 2828–2832.
  - See *Original Research.*

Science Schools.
- Desirability of establishing science schools for artizans, 2791–2795.
- Science classes for artizans at Andersonian University, 2802–2806.
- Objection to technical instruction in science schools, 2793–2820.

Scotland.
- Demand for scientific teaching in Scottish national schools, 2686, 2687.
- Large grants and contributions in aid of science in Scotland, 2688–2692, 2869.

Students.
- Glasgow University students; examinations and prizes; enter not well prepared; workers in laboratory, &c., 2656, 2678–2682, 2685, 2698–2715, 2760–2768, 2773–2776, 2865, 2866.
- Scientific instruction might be begun with students of 12 to 14 years; general scientific instruction earlier, 2781, 2782.

THOMSON, Sir W.—*Students*—cont.

Objection to students in science schools receiving technical instruction, 2793–2820, 2842–2859.

Students, in contact with persons engaged in scientific research, become themselves discoverers, 2860–2863.

Superannuation.

Professors' retiring allowance; objection to their not receiving it unless incapacitated from teaching, 2759.

Teachers. See *Professors.*

Technical Instruction.

Objection to technical instruction in science schools, except with regard to engineering, 2793–2820, 2842–2859.

Telegraphy.

Objection to technical instruction in telegraphy in schools; it must be learned in the workshop and office, 2858.

Universities.

Objection to candidates for university degrees having to perform a piece of work, 2833–2836.

University of Glasgow. See *Glasgow University.*

Workshops.

Technical instruction better gained in workshops than in science classes, 2793–2820, 2842–2859.

Zoology.

Zoology should be an independent professorship, 2741–2743.

RANKINE, PROFESSOR WM. JOHN MACQUORN. (Index of his Evidence.)

Aberdeen University.

Numerous bursaries at Aberdeen University, 9566.

Accommodation for Science Purposes.

Glasgow University has accommodation for a much-wanted collection of specimens of iron, wood, &c., 9513, 9514.

Age of Students.

20 is the average age of engineering students in Glasgow University, 9506.

Apparatus for Science Purposes.

Manipulation and construction of apparatus should be taught to students, 9511.

Much apparatus in Glasgow University physical laboratory is made by students, 9511.

Complete collection of specimens of iron, timber, building stones, &c. wanted at Glasgow University, 9513, 9514.

Arts.

Glasgow University engineering students wishing to become graduates have extra examination in two arts' subjects, 9529.

Assistant Professors, &c.

Assistant lecturer for naval architecture, &c. wanted at Glasgow University, 9513.

British Association.

British Association a good body to advise Government as to grants for research, 9558.

Bursaries.

Many bursaries at Glasgow University; all should be freely open to competition, 9566, 9567.

Certificates.

Certificates in engineering science granted by Glasgow University; they involve no literary subjects, 9506–9508, 9527–9529.

Chemistry.

Chemistry is one branch of Glasgow University engineering course, 9506.

Competitive Examinations. See *Examinations.*

Degrees.

Degree in engineering science, with honours, may be taken at Glasgow University, 9506.

Drawing.

Want of proficiency in drawing shown by Glasgow University engineering students, 9507.

Drawing is not taught in Glasgow University, although essential to a certificate of engineering; endowment wanted, 9507, 9513.

Importance of drawing in primary and technical education, 9510.

Education.

Drawing an important element of education, 9510.

RANKINE, Prof.—cont.

Engineering.

Engineering science at Glasgow University, 9504–9568.

Not pure practice, but application of scientific principles to practice, is taught in Glasgow University engineering department, 9506.

Glasgow University engineering instruction comprises mathematics, physics, chemistry, geology, civil engineering, and mechanics, 9506, 9537, 9538.

Certificates in engineering science granted by Glasgow University; no literary subjects required, 9506, 9527–9529.

Degree in engineering science, with honours, may be taken at Glasgow University, 9506.

Glasgow University engineering students; enter well prepared in mathematics, but not in drawing; increasing number; take good positions, 9506–9518, 9539–9547.

To engineers, a University should teach sciences applicable to engineering and mechanics, and application of scientific principles to practical purposes, 9512.

In engineering course at Glasgow University, machines are described with special regard to bearing of scientific principles, 9523–9526.

Increasing appreciation of advantages of Glasgow University engineering department, 9543–9551.

Evening Lectures.

Evening scientific lectures to men engaged in the day not practically useful, 9509, 9530–9532.

Examinations.

Voluntary entrance examination at Glasgow University for engineering students, which reduces time devoted to mathematics, 9506, 9508.

For Glasgow University engineering certificate examinations are passed in mathematics, chemistry, geology, civil engineering, mechanics, and drawing, 9506–9508.

On passing an examination, any student should be admitted into an applied science school, 9561–9565.

All bursaries at Glasgow, &c. should be, as some are, open to competitive examination, 9566, 9567.

Fellowships.

Advantage of fellowships, in view of research, 9515.

Geodesy.

Higher geodesy a subject for honours in Glasgow University engineering department, 9506.

Geology.

Geology (especially lithology) is one branch of Glasgow University engineering course, 9506.

Glasgow University.

Promotion of engineering science, &c. at Glasgow University, 9504–9569.

See *Professors, Students, &c.*

Government.

Government aid desirable for special cases of scientific research; also for institutions for testing materials, alloys, &c., 9515, 9554–9560.

British Association or Royal Society might advise Government as to awards for scientific research, 9555–9558.

Grants for Science Purposes. See *Income and Expenditure.*

Honours.

Degree in engineering science, with honours, may be taken at Glasgow University, 9506.

Income and Expenditure.

Funds wanted at Glasgow University for drawing, naval architecture, illustrative specimens, &c., 9513.

Government aid should be given towards permanent institutions for promoting research, 9515, 9554–9560.

Laboratories.

In Glasgow University physical laboratory students are instructed in manipulation of apparatus, 9511.

Lectures.

Lectures on engineering science, illustrated by experiments, are given at Glasgow University, 9506.

Scientific lectures in the evening to men engaged in the day not practically useful, 9509, 9530–9532.

Literature.

No literary subjects required for Glasgow University certificate of engineering, 9527–9529.

Lithology.

Lithology a subject of instruction in Glasgow University engineering course, 9506.

Machinery.

In Glasgow University engineering course, machines are described with special regard to scientific principles, 9523–9526, 9537.

RANKINE, Prof.—cont.

Mathematics.
Mathematics is one branch of Glasgow University engineering course; students enter well prepared, 9506–9508.

Mechanics.
Mechanics is one subject of instruction in Glasgow University engineering course, 9506.

Naval Architecture.
Naval architecture a subject for honours in Glasgow University engineering department, 9506.
Assistant lecturer for naval architecture desirable at Glasgow University, 9513.

Original Research.
Government may reasonably be applied to for aid in special cases of research, 9515.
Objection to endowment of any set of persons solely for purposes of research, 9515.
There might be permanent institutions for investigating strength of materials, alloys, &c., 9554–9560.
Advantage of professorships, fellowships, &c. to pursuit of research, 9515.

Physics.
Physics is one branch of Glasgow University engineering course, 9506.
Glasgow University students of physics instructed in manipulation of apparatus; advantage of this, 9511.

Practical Instruction.
Not pure practice, but application of scientific principles to practice, is taught in engineering department of Glasgow University, 9506.
Practical work in physics, chemistry, &c. is done by Glasgow University engineering students, 9506, 9511.
Separation requisite between practical and scientific study, 9509.
Practical skill of engineers, &c. should not be imparted or certified in a University, 9512.
Technical schools should be placed where practical and scientific instruction could be combined, 9548–9551.
Advantage of professors' access to constructors' workshops as regards practical instruction, 9550.

Professors.
Advantage to professors of having access to workshops of constructors, 9550.
One professor could not instruct more than 50 students, 9563.
See *Engineering.*

Professorships.
Approval of professorships which allow leisure for original research, 9515.

Royal Society.
Royal Society a good body to advise Government in cases of grants for scientific research, 9558.

Scholarships.
Advantage of scholarships in view of original research, 9515.
See *Bursaries.*

Schools.
Drawing should be taught in primary schools, 9510.
Technical schools should be established where practical and scientific instruction can be combined, 9548–9551.
Schools of applied science should be open to all students who pass an examination, 9561–9565.

Science.
Engineering science at Glasgow University, 9504–9568.
[illegible] scientific [illegible] on the day [illegible], 9509 [illegible] 30 [illegible].
Scientific and practical study should be separated, 9509.
Scientific knowledge, not practical skill, should be imparted and certified by Universities, 9512.
Increasing appreciation of science among employers, &c., 9511, 9516, 951[illegible], 9543, 95[illegible].
Where practical and scientific instruction can be combined there should be technical schools, 9548–9551.
Applied science schools should be open to all students after an examination, 9561–9565.
See *Original Research.*

Scottish Universities. See Glasgow University, Universities, &c.

Students.
Engineering students at Glasgow University; increasing number; enter well prepared in mathematics, not [illegible]; [illegible] good positions, 9506–9508, 9511, 9512.
Engineers' apprentices study at Glasgow University in winter, and work in summer, 9511, 9545.
Advantage of teaching to students manipulation of apparatus, 9511, 9537, 9538.

RANKINE, Prof.—*Students*—cont.
Poor students in Scottish Universities do not form majority; advantage to these of alternation of study and vacation, 9516–9519.
Students from India, Japan, Spain, &c. have attended Glasgow University, 9552.
Students should be admitted to applied schools on passing an examination, 9561–9565.
50 students enough for one professor, 9563.
Bursaries should be open to all students; advantage of bursaries to poor students, 9566, 9567.

Technical Instruction.
Scientific study should be separated from technical instruction, 9509, 9510.
Technical education should embrace drawing, 9510.
At Glasgow University, engineers' apprentices study in winter, and work in summer, 9511, 9545.
A small mechanical workshop might be desirable at Glasgow University, 9511, 9532*a*–9535.
Technical schools might be established where practical and scientific instruction could be combined, 9548–9551.
Advantage to professors, &c. of access to constructors' workshops, 9550.
In special schools of applied science, all students should be admitted on examination, 9561–9565.

Universities.
Universities should impart and certify scientific knowledge, not practical skill, 9512.
For promotion of research, Scottish (like English and Irish) universities should award fellowships, 9515.
Advantage of university vacations, in regard to scientific research, 9515.
Benefit of Scottish universities' system of six months' study and six months' vacation, 9516–9518.
Poor students do not form the majority in Scottish universities, 9519.

Vacations.
University vacations are valuable, in regard to original research, 9515.
Scottish system of six months' study and six months' vacation is very beneficial, 9516–9518, 9545.

Workshops.
Objection to a mechanical workshop, except on a small scale, for Glasgow University, 9511, 9532*a*–9535.
Advantage to professors of having access to constructors' workshops, 9550.

YOUNG, PROFESSOR JOHN, M.D. (Index of his Evidence.)

Artizans.
Artizans do not avail themselves of scientific teaching in Glasgow, 9593, 9609.

Arts.
No inducement to arts' students at Glasgow University to attend natural science classes, 9578.
For Glasgow B. Sc. degree, requirement in arts is too great, 9597.

Assistant Professors, &c.
Assistants not provided for professors of natural history, physiology, &c. in Glasgow University, 9576, 9600.

Certificates. See Science.

Colleges.
Everything relating to normal training colleges should be under one department, 9589–9591.

Degrees.
Glasgow University B. Sc. degree; for natural science, requirement in arts is too great, 9578, 9597.
Scottish University degrees accepted by Science and Art Department as qualification for science teacher, 9597.

Education.
Educational deficiencies of students at Glasgow University, 9579–9587.
Injurious results of lowering educational standard in Scottish training schools, 9579–9587, 9591.
Training colleges and elementary schools should be under one department, 9588–9592.
Indifference to scientific education shown by profession of civil engineers, 9595.

Education Department.
Difficulties from confused functions of Education and Science and Art Departments, 9588–9591, 9594.

Engineering.
Engineering students at Glasgow University; they have to study geology; mining lectures wanted for them; advantage to them of the winter courses, 9571–9579, 9591, 9601, 9606–9608.

YOUNG, Prof.—*Engineering*—cont.
Want of interest in education shown by civil engineers, 9595.
Scientifically, the profession of engineering is in a worse position than that of medicine, 9595.

Geology.
Objection to combination of geology and zoology in Glasgow University chair of natural history; endeavour to remedy this, 9571–9575, 9610, 9611.
Ignorance of geology shown by natural history students at Glasgow University, 9579.
Want of appreciation of geology by engineers, 9579.
Want of an assistant for mining in geological course at Glasgow University, 9601.

Glasgow.
Endeavour to establish a mining school at Glasgow; not successful, 9601.
Technical schools contemplated at Glasgow; not to embrace mining; will be useless if science be not taught in schools, 9601, 9612.

Glasgow University.
Promotion of natural history, geology, &c. at Glasgow University, 9569–9614.
See *Professors, Students,* &c.

Government.
Government should aid endowment of chair of geology at Glasgow University, 9572, 9611.

Histology.
Assistant wanted at Glasgow University for histology, 9601.

Hunterian Museum (Glasgow).
Hunterian Museum; it might be used for instruction of science teachers, if means were furnished, 9572, 9598.

Income and Expenditure.
Glasgow University professors' emoluments; increase forbidden by Act, 9572, 9576, 9600.
Science and Art Department payments in Scotland are for children whose parents have not more than 100*l.* per annum, 9593–9595.
Want of funds for physiological instruction at Glasgow University, 9600.
Government should aid endowment of chair of geology at Glasgow University, 9611.

Lanarkshire.
Want of appreciation of science among mining proprietors, &c. in Lanarkshire, 9602, 9603.

Languages.
Latin, Greek, French, and German are omitted from requirements in Scottish training schools, 9579.

Lectures.
Lectures at Glasgow University; 50 on zoology given to medical students, 9571, 9574, 9575.
Lectures at Andersonian University and Mechanics' Institution in Glasgow are attended by clerks, divinity students, &c., not by workmen, 9593.
In science teaching there is too much lecturing, and too little demonstrative examination, 9599.
Failure of lectures on practical mining given in Glasgow, 9601.

Managers of Mines.
Ignorance of colliery managers, &c. as regards science, 9601–9605, 9610.

Mechanics' Institution (Glasgow).
Glasgow Mechanics' Institution, intended for workmen, is frequented by clerks, divinity students, &c., 9593.

Medicine.
Glasgow University medical students; deficiency of their education on entrance, 9571, 9575–9591.
Profession of medicine not in such a bad position, scientifically, as that of engineering, 9595.

Mines' Regulation Bill.
Mines' Regulation Bill should require mining managers to take a science certificate, 9613, 9614.

Mining.
Want of assistant for mining instruction at Glasgow University, 9601.
Endeavour to establish a mining school at Glasgow; failure, 9601.
Technical schools contemplated at Glasgow do not embrace mining, 9601.
Indifference of mining proprietors, &c. to scientific teaching, 9602–9605, 9610.
Government should insist on mining managers taking a science certificate, 9603–9605, 9613, 9614.

YOUNG, Prof.—cont.

Natural History.
Natural history department at Glasgow University; objection to combination of zoology and geology; want of assistants and resources for physiology, &c., 9571–9614.
Failure of cheap anatomical and physiological demonstrations at Glasgow, 9594.

Payments on Results.
Payments on results in Scotland are for children whose parents have not more than 100*l.* per annum, 9593–9595.

Physiology.
Inefficient teaching of physiology at Glasgow University, 9600.

Practical Instruction.
Practical instruction essential for science teachers, &c., 9599.
Lectures on practical mining in Glasgow failed, 9601.

Professors.
Professor of natural history at Glasgow University; lectures on zoology and geology; his want of an assistant, 9571–9579.
Professor of physiology in Glasgow University; his small income, lack of assistants, &c., 9600.
Professors should not have to do professional work to make an income, 9600.

Professorships.
Objection to combination of zoology and geology in natural history chair at Edinburgh University, 9571–9575, 9610, 9611.

Religion.
Failure of inducement to Glasgow University theological students to attend natural history courses, 9577.
Divinity students attend Andersonian University and Mechanics' Institution in Glasgow, 9593.

Schools.
Lowering educational standard in Scottish training schools; injurious to Glasgow University, medical profession, &c., 9579 9587, 9591.
Good standard of Edinburgh University students owing to good schools in Edinburgh district, 9585.
Confusion of Departments of Education and Science and Art in regard to elementary schools, 9588–9591.
Science teaching wanted in Scottish schools; Universities should instruct teachers, 9593–9599, 9606–9608, 9612.
Technical schools contemplated at Glasgow do not embrace mining; a mining school failed, 9601.

Science.
Promotion of science in Glasgow University, 9569–9614
Want of encouragement of science in Scotland, 9593–9595, 9602, 9603, 9610.
Glasgow technical schools useless without scientific teaching in elementary schools, 9612.
Government should insist on mining managers, &c. taking certificates in science, 9613, 9614.

Science and Art Department.
Confused functions of Departments of Education and Science and Art detrimental to education, 9588–9591, 9594.
Bad effect of Science and Art Department payments in Scotland being confined to children whose parents' incomes do not exceed 100*l.*, 9593–9595.
University degree accepted by Science and Art Department as qualification for science teacher, 9597.
Scottish Universities should follow South Kensington plan of instructing science teachers, 9598.

Science Teachers. See *Teachers*

Scotland.
Promotion of science in Scotland; every parish should encourage science in schools; present want of encouragement, 9569 9614.

South Kensington. See *Science and Art Department.*

Students.
Glasgow University students; are of a lower status than those of Edinburgh, &c.; winter instruction advantageous to them, 9571–9591, 9606–9608.

Teachers.
Higher education of pupil teachers in Scotland essential to success of Glasgow University, 9586.
Confusion of Whitehall and South Kensington Departments in regard to pupil teachers, 9588.
Want of encouragement for Scotch teachers to study science; Glasgow University should instruct them, 9593–9599, 9606–9608.
University degree accepted by Science and Art Department as qualification for science teacher, 9597.

YOUNG, Prof.—cont.

Technical Instruction.
Technical schools contemplated at Glasgow do not embrace mining, 9601.
Glasgow technical schools; not to embrace mining: they will be useless if science be not taught in elementary schools, 9612.

Training Schools. See *Schools.*

Universities.
Danger to Scottish Universities of making excessive requirements for science degrees, 9597.
Scottish Universities should be able to instruct teachers like South Kensington, 9598, 9599.

Universities' Act.
Emoluments of Glasgow professors forbidden by Universities' Act to be increased, 9576.

Vacations.
Vacations at Glasgow University vary; many men study only in winter, 9606–9608.

Workshops.
Glasgow engineering students can pass the winter in the University, and the summer in their workshops, 9608.

Zoology.
Objection to combination of zoology and geology in Glasgow University natural history chair, 9571–9575, 9610, 9611.
Zoology is taught to medical students at Glasgow University, 9571–9578.

THOMSON, PROFESSOR ALLEN, M.D. (Index of his Evidence.)

Accommodation for Science Purposes.
Accommodation in Glasgow University for teaching science to schoolmasters, 9824–9841.
At Glasgow University, accommodation for five departments will be desirable, 9857, 9929–9933.

Age of Students.
Age of Glasgow University students estimated to average 19 years, 9872–9881.

Agriculture.
Analyses of soils, &c. for Highland Society carried on in Glasgow University, 9835–9839.

Anatomy.
Instruction in anatomy at Glasgow University: professorship includes botany; laboratory essential in new buildings, 9791–9933.
Zoology and anatomy instruction should be separated from geology and mineralogy at Glasgow University, 9797–9799.
Desirability of Scottish veterinary institutions being utilised for study of anatomy, 9800, 9801.
Important anatomical department in Glasgow Hunterian Museum; class museum also, 9888–9903.

Apparatus for Science Purposes.
Glasgow University, to give instruction to schoolmasters, would require more apparatus, 9825.
Dried herbarium, systematic collection of plants, &c., at Glasgow University, 9902, 9903.
Valuable instruments in Glasgow Astronomical Observatory, 9904.
Apparatus for natural philosophy at Glasgow University no fund for it from University, 9909.

Artizans.
Evening lectures on science, though desirable for artizans, cannot carry education far, 9811.

Arts.
Science neglected in Scottish arts' degrees, 9858, 9865.
Glasgow University has full course of arts, before theology, for divinity students; for B.Sc., candidates choose subjects from curriculum of arts, 9859, 9923.

Assistant Professors, Demonstrators, &c.
Demonstrator and assistants for anatomy course at Glasgow University, 9796.
Instruction of schoolmasters at Glasgow University would require additional assistants, 9821, 9825.
Advantage of skilled assistants in universities, for research, training as professors, &c., 9825–9827, 9850–9856.
Glasgow University chemical department has two skilled assistants; also assistants for analyses, 9830–9838.
For natural philosophy at Glasgow University one assistant is provided, and three are paid by professor, 9842–9847.
Assistant for physiology at Glasgow University gives microscopical demonstrations, 9857.

THOMSON, Prof. ALLEN—cont.

Astronomical Observatory (Glasgow).
Astronomical Observatory at Glasgow belongs to University; professor lectures in University, and gives practical instruction in Observatory, 9902–9908.

Biology.
Biological science is one requirement for Glasgow natural science degree, 9867, 9868.

Botanic Garden (Glasgow).
Botanic Garden at Glasgow is connected with teaching of University, 9902, 9903.

Botany.
Glasgow University professor of anatomy is also professor of botany; but there is a distinct professor of botany, 9792–9794.
Herbarium, botanical library, &c. of Professor W. Arnott purchased by Glasgow University, 9901, 9902.

Bursaries.
Scottish University bursaries might be used to encourage school teachers to study science, 9821.
Glasgow University has large sums for bursaries, &c., 9905.

Chemistry.
General chemical course at Glasgow University should be limited to principles; applications might be taught elsewhere, 9802–9808.
New chemical laboratory in Glasgow University has room for 40; there are two skilled assistants, 9828–9841, 9930–9932.

Children.
Boys should have many educational subjects brought before them, to ascertain their bias, 9880.

Cramming.
Cramming easily detected in examination, 9886, 9887.

Degrees.
Practical chemical course at Glasgow University, as required for medical degrees, 9840, 9841.
Science neglected in Scottish arts' degrees, 9858.
Science degrees in Scotland; distinct faculty of science essential for these; they qualify for voting, 9858–9883, 9864, 9865.
At Glasgow University, there are to be degrees in law, engineering and mechanics, and natural science; B.Sc. to be instituted; D.Sc. might be given for original work, 9867, 9917–9928.
Science degrees should be given on an elastic system, 9868–9871.

Education.
Various educational subjects should be brought before boys, to ascertain their bias, 9880.

Engineering and Mechanics.
Degree in engineering and mechanics to be instituted in Glasgow University, 9867, 9868.

Evening Instruction.
Evening scientific lectures desirable for workmen, 9811.

Examinations.
Thorough practical system of examination, especially in teaching, is very important, 9884–9887.
Evil of preparation solely for examination; cramming easily detected, 9884–9887.
Glasgow B.Sc. to be given upon examination; literary subjects may mostly be avoided, 9917–9928.

Faculties.
Distinct faculty of science in Scottish Universities will be essential, 9858–9883.
In Glasgow University, the faculties are, arts, divinity, law, and medicine, 9867.

Geology.
Desirable to separate chair of zoology and geology at Glasgow University, 9797–9799.
Geology is one section of requirements for Glasgow University natural science degree, 9867, 9868.

Glasgow University.
Science teaching in Glasgow University, 9791–9933.
See *Professors*, *Students*, &c.

Highland Society. See *Agriculture.*

Honours.
Honours in natural science allowed by Universities' Commission to be taken at Glasgow, 9861.

Hunterian Museum (Glasgow).
Hunterian Museum, Glasgow; anatomical department important; funds, and an officer for collection, &c. of specimens, are wanted, 9888–9901, 9910, 9916.

THOMSON, Prof. ALLEN—cont.

Income and Expenditure.
  Two assistant chemical professors at Glasgow University receive each 100*l.* a year; professor of astronomy 220*l.*, 9830-9834, 9906, 9908.
  Museum, and 8000*l.*, left to Glasgow University by Dr. Hunter; maintained by University funds; keeper and assistant have 100*l.* each, 9888-9901.
  Glasgow University has considerable funds for bursaries, salaries, &c., but little available income, 9905.

Laboratories.
  Laboratory instruction in anatomy given at Glasgow University; accommodation sufficient for instruction of school teachers, 9796, 9824, 9825.
  Chemical laboratory in Glasgow University; room for 40; soils, &c. analysed, 9828-9841, 9930-9933.
  Students of anatomy at Glasgow University are examined practically in laboratory, 9885.
  In new buildings of Glasgow University five departments require laboratories, 9930-9933.

Languages.
  In new scheme for science degrees at Glasgow University, modern languages should be recognised, 9868.

Law.
  Degree in law at Glasgow University, 9867, 9868.

Lectures.
  Five lectures a week is customary in Scotland, 9806.
  Evening science lectures desirable for workmen, 9811.
  Lectures on astronomy at Glasgow are given in the University; practical instruction in Observatory, 9908.

Literature.
  In examinations for B. Sc. degree at Glasgow, literary subjects may mostly be avoided, 9917-9928.

Managers.
  Managers of workmen should be fully educated in principles of science, 9811.

Mathematics.
  Mathematics is generally taught in higher schools of Scotland, 9815.

Mechanics. See *Engineering and Mechanics.*

Medicine.
  Glasgow University medical course; students attend anatomy two years; applied chemistry instruction valuable for them, 9795, 9802-9808, 9840, 9841.
  Desirability of using veterinary institutions for study of anatomy, 9800, 9801.
  New Western Infirmary at Glasgow will serve for clinical instruction of University Medical School, 9930.

Meteorological Department.
  Glasgow Astronomical Observatory is a station of the Meteorological Department, 9908.

Museums.
  Hunterian Museum in Glasgow University; anatomical department an important one; wants funds, 9888-9901.
  Collections in Glasgow University; illustrative class museums for anatomy, &c., 9901, 9909.
  Museums spread over the country desirable; specimens might be collected in towns, &c., 9910-9916.

Natural History.
  Natural history specimens for museums could be collected in great towns; Glasgow Hunterian Museum might have an officer for this purpose, 9910-9916.
  Laboratory for natural history in new University buildings of Glasgow, 9932.

Natural Philosophy.
  Natural philosophy course at Glasgow University; it attempts too much; there are four assistants, 9803, 9842-9847.
  Engineers, clergymen, &c. work in physical laboratory of Glasgow University, 9842-9849.
  Glasgow University divinity students study physics before they begin theology, 9859.
  Laboratory for natural philosophy department in new University buildings at Glasgow, 9930-9932.

Original Research.
  Glasgow University might confer a doctorate of science for original work, 9928.
  Advantage of skilled assistants in universities for promotion of research, 9826, 9827, 9850-9856.
  University professors should be contributors to science, and have leisure for research, 9845, 9850-9856.

Palæontology.
  If Glasgow University chair of zoology and geology were divided, palæontology might be taught in both courses, 9797-9799.

Physics. See *Natural Philosophy.*

THOMSON, Prof. ALLEN—cont.

Physiology.
  Desirable that chemistry should be taught in its relation to physiology, 9808.
  New buildings of Glasgow University will have accommodation for practical physiology, 9857, 9932.

Practical Instruction.
  Practical instruction and examination in anatomy at Glasgow University, 9796, 9885.
  Advantage of using veterinary institutions for practical instruction in anatomy, 9800, 9801.
  Practical chemistry course in Glasgow University; 100 medical students in summer, 9828-9841.
  Microscopical and practical demonstrations in physiology at Glasgow University; provision for this made in new buildings, 9857.
  A sufficient course of practical physiology is much wanted in Glasgow, 9857.
  Practical instruction given in Glasgow Astronomical Observatory, 9902-9909.

Professors.
  Professor of anatomy of Glasgow University is also, by his commission, professor of botany, 9794.
  Desirability of having assistants in Universities training for professors, 9826, 9827.
  A university professor should contribute to science, and have leisure for research, 9845, 9850-9856.
  Professors of science at Glasgow University should have a faculty of their own, 9866, 9882, 9883.
  Professor of astronomy at Glasgow gives lectures in University, and practical instruction in Observatory, 9902-9909.

Professorships.
  Separation between chair of zoology and geology desirable at Glasgow University, 9797-9799.
  Desirable to establish a faculty of science at Glasgow University, from existing professorships or new ones, 9866.

Religion.
  Divinity students of Glasgow University go through a full course of arts before beginning theology, 9859.

Scholarships.
  Glasgow University has considerable sums for scholarships, &c., 9905.

Schools.
  Want of science teaching in elementary and higher schools of Scotland, 9809-9815.
  Deficiencies of Scottish school teachers in regard to science; Universities should aid them, 9809-9825.
  Advantage of local museums with respect to science teaching in schools, 9912.

Science.
  Promotion of science in Glasgow University, 9791-9933.
  Want of scientific instruction in Scottish schools, 9809-9825.
  Evening science lectures desirable for workmen, but they cannot carry education far; managers should be educated fully, 9811.
  Science degree recognised in Scotland as a qualification for voting, 9864.
  For promotion of science, and establishment of a satisfactory degree, in Scottish Universities, a distinct faculty of science will be essential, 9858-9883.

Science and Art Department.
  Universities in Scotland ought to instruct teachers similarly to South Kensington, 9823-9825.

Scottish Universities. See *Universities.*

Students.
  Two years' course for students of anatomy at Glasgow University; they have practical examinations, 9795, 9886.
  A large number of school teachers become students of Glasgow University, 9819.
  Glasgow University chemical laboratory has 20 to 25 students; 100 medical students in summer, 9828-9841.
  Students of natural philosophy at Glasgow University are training for medicine, engineering, the Church, &c., 9842-9847.
  Divinity students at Glasgow University go through a full course of arts before beginning theology, 9859.
  Young students should be allowed choice of subjects, 9872-9881.
  Students persist in cramming, notwithstanding its easy detection, 9886, 9887.

THOMSON, Prof. ALLEN—cont.

Teachers.
Desirability of school teachers having scientific instruction, with prizes, &c.; universities should instruct them, 9809–9825.

Technical Instruction.
Desirable to separate practical applications from chemistry course at Glasgow University, 9802–9808.

Universities.
Scottish universities ought to instruct teachers, as is done at South Kensington, 9823–9825.
Advantage of assistants in universities, in view of research, training for professors, &c., 9826, 9827, 9850–9856.

THOMSON, Prof. ALLEN—*Universities*—cont.
University professors should be contributors to science, and have leisure for research, 9845, 9850–9856.
For science degrees, &c. in Scottish universities, a distinct faculty of science will be essential, 9858–9882.

Veterinary Institutions.
Desirability of utilising Scottish veterinary institutions for study of anatomy, 9800, 9801.

Zoology.
Separation of Glasgow University chair of zoology and geology desirable, 9797–9799.

Anderson's University (Glasgow).

McCLELLAND, JAMES, Esq. (Index of his Evidence.)

Accommodation for Science Purposes.
For accommodation of students of anatomy, Anderson's University is only inferior to that of Glasgow; room for 2,640 students, 9961, 9962, 9984.

Anatomy.
162 students in anatomy course at Anderson's University; practical instruction given, 9958–9962.

Anderson's University (Glasgow).
Scientific instruction at Anderson's University, 9934–9989.
Governing trustees of Anderson's University comprise tradesmen, agriculturists, artists, manufacturers, mediciners, lawyers, divines, philosophers, and kinsmen and namesakes of the founder, 9936–9939.
See *Professors, Students, &c.*

Apparatus for Science Purposes.
Ample material for anatomical instruction at Anderson's University, 9962.

Artizans.
Scientific instruction of artizans at Anderson's University; instruction of workmen chief aim of foundes, 9966-9978.

Bursaries.
For technical chemistry at Anderson's University there are eight bursaries of 50*l.* each, 9987.

Chemistry.
Chemical course at Anderson's University; 141 attending; practical instruction given, 9950-9956.
Lectures on chemistry given to ladies at Anderson's University, 9968.
Establishment of chair of technical chemistry, and bursaries, at Anderson's University, 9985–9987.

Contributions for Science Purposes.
Valuable gifts of Messrs. Young, Ewing, and Freeland to Anderson's University, 9985–9987.
See *Grants for Science Purposes.*

Degrees.
Anderson's University cannot grant degrees, 9991–9993.

Evening Instruction.
Popular evening science classes at Anderson's University; great diversity in the occupations of those who attend, 9966 9969, 9988–9990, 10,003, 10,004.

Examinations.
Voluntary examinations follow the popular courses at Anderson's University; many students also attend examinations of Science and Art Department, 9973 9976.

Faculties.
Anderson's University professors are classified into faculties of arts, medicine, law, and theology, 9912.

Glasgow.
Glasgow Secular School; established 22 years; going on successfully, 10,005–10,014.

Government.
Endowment from Government would enable Anderson's University to train teachers, 10,000–10,016.

Income and Expenditure.
No endowments attached to faculties in Anderson's University; professors depend on fees; students pay 2*s.* 6*d.* per course, 9913 9916, 9972 9983.
Gifts to Anderson's University for teaching mechanics, anatomy, music, &c. to working class, 9969.

McCLELLAND, J., Esq.—cont.

Laboratories.
Laboratory instruction in chemistry given at Anderson's University, 9950–9956.

Ladies.
Scientific instruction of ladies at Anderson's University, as projected by founder, 9966–9968.
Large number of ladies attend musical courses in Anderson's University, 9968.

Lectures.
Lectures on natural philosophy, mathematics, anatomy, &c. at Anderson's University, 9948–9964.
Popular scientific lectures at Anderson's University to working class and ladies, 9966–9972.

Libraries.
Medical and other libraries at Anderson's University; also library for popular classes, 9980–9983.

Mathematics.
Mathematical instruction at Anderson's University; 120 attended last session, 9949, 9950.

Mechanics' Institutes.
Anderson's University popular science lectures originated mechanics' institutes, 9968.

Medicine.
Faculty of medicine at Anderson's University; 10 professors and 424 students, 9942, 9957–9965, 9982.
Practical instruction is given in the class of Institutes of Medicine at Anderson's University, 9859–9962.

Music.
Musical instruction at Anderson's University; large number of ladies attend; gift of 3,000*l.* for this purpose, 9968–9970.

Natural Philosophy.
Natural philosophy courses at Anderson's University; 108 students last session; lectures are independent of mathematics, 9948, 9949.

Practical Instruction.
Practical instruction in chemistry, anatomy, &c. given at Anderson's University, 9950–9956.

Professors.
Professors of Anderson's University; they are classified into faculties of arts, medicine, law, and theology; each professor has 100*l.* and share of fees, 9942, 9964, 9965, 9972, 9979.

Professorships.
Chair of technical chemistry instituted at Anderson's University, 9985–9987.

Schools.
Students from the Glasgow secular schools have gained high positions by attending Anderson's University, 9977.
Glasgow Secular School instituted 22 years ago; still successful, 10,005–10,014.
Teachers of Scottish schools might be trained in science at Anderson's University, 9996–10,016.

Science.
Promotion of science at Anderson's University, Glasgow, 9958-9962.
Successful introduction of science teaching in Glasgow Secular School, 10,005-10,014.

Science and Art Department.
Students of popular courses in Anderson's University undergo examinations of Science and Art Department, 9973 9978.

McCLELLAND, J., Esq.—cont.

Students.

793 science students, and 1,457 in popular classes, at Anderson's University, 9947–9983.

For working men and ladies the popular lectures at Anderson's University were designed, 9966–9968.

Anderson's University students do not belong to the upper class; evening class students show great diversity of occupations, 9988-9990, 10,003, 10,004.

Teachers.

Anderson's University a desirable place for training scientific teachers for schools, 9996–10,016.

Technical Education.

Chair of technical chemistry, and bursaries, at Anderson's University, 9985–9987.

YOUNG, JAMES, Esq. (Index of his Evidence.)

Accommodation for Science Purposes.

Accommodation at Anderson's University for teaching technical chemistry, but not natural philosophy, 10,045, 10,046.

Age of Students.

Competitors for technical chemistry bursaries at Anderson's University must be 16 to 17, 10,036.

Anderson's University.

Promotion of science at Anderson's University, 10,020–10,058.

Bursaries.

Advantage to poor students of Anderson's University bursaries, 10,033–10,038.

Chemistry.

Necessity of scientific knowledge for improving chemical arts, 10,039–10,043.

Chair of technical chemistry at Anderson's University; its success, 10,025–10,044.

Examinations.

Anderson's University technical chemistry bursaries are awarded after examination, 10,036.

Glasgow.

Promotion of science in Glasgow, 10,020–10,058.

Grants for Science Purposes.

Want of endowment felt at Anderson's University, in loss of professors, 10,047.

Public money could not be devoted to a better purpose than teaching of science, 10,053.

Manufactures.

Development of manufactures will result from increased knowledge of scientific principles, 10,039–10,043.

Natural Philosophy.

Applications of natural philosophy should be taught at Anderson's University; prospect of obtaining a class, 10,031, 10,045, 10,046.

Original Research.

Professors should be devoted to original research, 10,049–10,051.

Practical Instruction.

Anderson's University students of technical chemistry do practical work, 10,026.

Professors.

Professor of technical chemistry at Anderson's University, 10,025, 10,054–10,057.

Want of endowment at Anderson's University has resulted in loss of professors, 10,047.

For training teachers at Anderson's University, professors would require assistance, 10,048, 10,049.

Original research an important duty of a professor, 10,049–10,051.

YOUNG, J., Esq.—cont.

Professorships.

Chair of technical chemistry founded at Anderson's University; its success, 10,025–10,044.

Professorship for applied natural philosophy wanted at Anderson's University; prospect of obtaining it, 10,031, 10,045, 10,046.

Science.

Promotion of science in Anderson's University, Glasgow 10,020–10,058.

Improved manufactures a result of improved knowledge of principles of science, 10,039–10,043.

No better application of public money than to teaching of science, 10,053.

Students.

Students of technical chemistry at Anderson's University; competitors for bursaries must be 16 to 17. 10,025–10,038.

Teachers.

Teachers might be instructed at Anderson's University, 10,048, 10,049.

Technical Instruction.

There should be no attempt to teach actual work in a school of applied science, 10,027.

At Anderson's University applied natural philosophy should be taught, 10,031.

HARVEY, ALEXANDER, Esq. (Index of his Evidence.)

Anderson's University (Glasgow).

Eminent manufacturers formerly students at Anderson's University, 10,064 10,070.

Mechanical as well as physical chairs are wanted at Anderson's University, 10,065.

Chemistry.

Importance of applications of chemistry to manufactures, 10,059–10,078.

Laboratories.

Applied science, not actual work, can be learned in laboratories, 10,061–10,063.

Manufactures.

Value of scientific knowledge in connexion with manufactures, 10,059–10,078.

Instances of students of Anderson's University becoming distinguished scientific manufacturers, 10,066–10,070.

Applications of chemistry to manufactures; illustrations of its importance, 10,059–10,078.

Mechanics.

Chairs for mechanics, as well as physics, should be instituted at Anderson's University, 10,065.

Physics.

Chair for physics desirable for Anderson's University, 10,065.

Practical Instruction.

Practical applications of science, but not actual work, can be taught in schools, 10,061–10,063.

Professorships.

At Anderson's University mechanical as well as physical chairs should be established, 10,065.

Schools.

Principles of science and their applications could be taught in schools, 10,061–10,063.

Science.

Advantages of scientific knowledge in connexion with manufactures, 10,059–10,078.

Students.

Many Anderson's University students have become distinguished scientific manufacturers, 10,066–10,070.

University of St. Andrew's.

TULLOCH, REV. JOHN, D.D. (Index of his Evidence.)

Accommodation for Science Purposes.

St. Andrew's University; accommodation wanted for library, instruction of school teachers, &c., 9662–9664, 9670–9682, 9695–9701.

Age of Students.

St. Andrew's University mathematical students are from 14 to 18 years of age, 9620, 9621.

Anatomy. See under *Physiology.*

TULLOCH, Rev. Dr.—cont.

Apparatus for Science Purposes.

Scientific apparatus much wanted at St. Andrew's University; grants inadequate, 9643, 9675–9677, 9683–9686, 9695–9701.

Artizans.

Evening science classes for artizans, &c., at Dundee, proposed, 9647.

Tulloch, Rev. Dr.—cont.

Arts.
St. Andrew's arts' degree; chemistry required; examination by professors and paid examiner, 9627, 9628, 9702.

Assistant Professors.
Want of assistant professors at St. Andrew's University; consolidation of bursaries might remedy this, 9619, 9676, 9689–9694.
St. Andrew's University professors, with assistants, &c., could instruct schoolmasters in science, 9695–9701.
An institution at Dundee connected with St. Andrew's University would necessitate appointment of assistant professors, 9703, 9704.

Bursaries.
Bursaries in St. Andrew's University; none for science; University cannot consolidate them, 9689–9693.

Chemistry.
Chemistry course at St. Andrew's University; it is required for arts' degree, 9625–9628.

Colleges.
Colleges at St. Andrew's University; distinct foundation and revenues; poorer than University; their difficulties from Crown teinds; buildings kept up by Government, 9626, 9631, 9656 9682.

Contributions for Science Purposes. See *Income and Expenditure.*

Degrees.
St. Andrew's University degrees; chemistry required for arts' degree, 9627-9631.

Dick Bequest.
Dick Bequest has elevated standard of school teachers in Scotland, 9700.

Dundee.
Desirability of extending St. Andrew's University teaching to Dundee; University staff must be increased, 9646–9651, 9673, 9674, 9703, 9704.

Endowments. See *Income and Expenditure.*

Evening Instruction.
Proposal to institute evening science classes, in connexion with St. Andrew's University, at Dundee, 9647.

Examinations.
No examination for course on anatomy and physiology at St. Andrew's University, 9637.
Examination in arts at St. Andrew's University is conducted by professors and paid examiner, 9702.
Scientific, mental science, and classical departments at University of St. Andrews have paid examiners, 9702.

Hall for Students.
College Hall for students of St. Andrew's University; the only one of its class in Scotland, 9646.

Hygiene.
Instruction in hygiene at St. Andrew's University, 9632, 9636.

Income and Expenditure.
St. Andrew's University professors' endowments; must not be paid from University income, 9634, 9658.
Inadequate grants for scientific apparatus at St. Andrew's University, 9643.
Gifts for science purposes to St. Andrew's University, from Mr. Duncan, Dr. Neil Arnott, &c., 9644.
Funds of University of St. Andrew's; capital fund about 21,000*l.*, matriculation fees, 180*l.*, graduation, 500*l.*; 600 guineas a year from Stationers' Hall, 9652–9663.

Libraries.
Library of St. Andrew's University contains 110,000 vols.; extension much wanted, 9655, 9660–9669.

Mathematics.
Mathematical instruction at St. Andrew's University; three classes; students range from 14 years, 9616–9622.

Museums.
St. Andrew's University has a good museum; mainly a local collection; geology, antiquity, &c. are represented, 9638 9642, 9687, 9688.

Natural History.
Peculiar position of natural history chair at St. Andrew's University; no regular teaching, 9629–9631.

Natural Philosophy.
Natural philosophy instruction at St. Andrew's University; students (including theological students) are obliged to attend, 9616, 9623, 9624.

Patronage.
Chairs at St. Andrew's University are in the hands of private patrons, 9629, 9630.

Tulloch, Rev. Dr.—cont.

Physiology.
Instruction in anatomy and physiology at St. Andrew's University is devoted greatly to hygiene, 9632–9637.

Practical Instruction.
Practical instruction in chemistry is given at St. Andrew's University, 9625.
Want of practical instruction in science for Scottish schoolmasters; St. Andrew's University, with extended resources, could remedy this, 9695–9701.

Prizes.
Prizes of books, &c. (no scholarships) for promotion of science at St. Andrew's University, 9644, 9645.

Professors.
Professor of mathematics at St. Andrew's University; has three classes; no assistant, 9616–9622.
Professor of natural philosophy at St. Andrew's University; has one class, 9623, 9624.
Professor of chemistry at St. Andrew's University; gives lectures and practical instruction, 9625.
Professor of natural history at St. Andrew's University; can get a class only occasionally, 9629–9631.
Professor of anatomy and physiology at St. Andrew's University; lectures greatly on hygiene, 9632–9637.
More professors will be requisite at St. Andrew's if instruction be given in Dundee, 9673, 9674, 9703, 9704.
Professors of St. Andrew's University, with assistants, could instruct schoolmasters in science, 9695–9701.

Professorships.
Peculiar position of chairs of natural history, &c. at St. Andrew's University; three chairs have private patrons, 9625–9631.
Five chairs (mathematics, natural philosophy, chemistry, natural history, and anatomy and physiology), constitute the scientific department of St. Andrew's University, 9615–9704.

Religion.
St. Andrew's University students, intended for the Church, have to study mathematics and natural philosophy, 9624.
Advantage to theological students of instruction in physiology and hygiene, 9632–9637.
Many theological students of St. Andrew's University (owing to Church difficulties) have become teachers of science, &c., 9695.

Saint Andrew's University.
Scientific instruction in St. Andrew's University, 9615–9704.
See *Professors, Students, &c.*

Scholarships.
No scholarships for science at St. Andrew's University, 9644, 9645.

Schools.
A large number of students from St. Andrew's University become teachers of science, &c. in schools, 9695.

Science.
Scientific departments in University of St. Andrew's, 9615–9704.
No bursaries specially for science in St. Andrew's University, 9689–9693.

Science and Art Department.
St. Andrew's University (like South Kensington) should be capable of giving practical instruction to science teachers, 9695–9701.

South Kensington. See *Science and Art Department.*

Stationers' Company.
600 guineas a year paid by Stationers' Company to St. Andrew's University for commuting right to books, 9655.

Students.
Students of St. Andrew's University; their fees; many students become school teachers, 9616–9622, 9652–9654, 9695.
St. Andrew's University students (theological inclusive) have to attend lectures in mathematics and natural philosophy, 9624.
Advantage to St. Andrew's University theological students of the instruction in physiology and hygiene, 9632, 9636.
Proposal to institute evening science classes for artizan students, &c. at Dundee, 9647.

Teachers.
University of St. Andrew's has furnished many teachers of science, &c., 9695, 9696.

Tulloch, Rev. Dr.—*Teachers*—cont.
St. Andrew's University, with assistants, &c., could instruct teachers practically, 9697–9701.
Standard of school teachers in Scotland has been elevated by Dick Bequest, 9700.

Universities' Commission.
Arrangement of chairs of chemistry, natural history, &c. by Universities' Commission, 9626–9629, 9658.
Paid examiners at St. Andrew's University authorised by Universities' Commission, 9702.

University of Saint Andrew's. See *Saint Andrew's University.*

SWAN, Professor WILLIAM, LL.D. (Index of his Evidence.)

Aberdeen University.
Provision for assistants, class expenses, &c. at Aberdeen University, 9729–9733.

Accommodation for Science Purposes.
Natural philosophy department at St. Andrew's University; apparatus room crowded; extension capable, 9714–9719.
Physical laboratory at St. Andrew's University would require Government grant, 9718.

Acts of Parliament. See *Parliament.*

Age of Students.
Natural philosophy department students at St. Andrew's University are generally under 20 years, 9706–9713.

Apparatus for Science Purposes.
Natural philosophy apparatus at St. Andrew's University; good, but insufficient; 100*l.* a year should be allowed, 9715–9758.

Artizans.
Artizan students at St. Andrew's University, 9713.
Dundee artizans could not go to St. Andrew's; they must have lectures in Dundee, 9745, 9754–9756.

Arts.
St. Andrew's University students stay four years for arts' degree, except they undergo entrance examination in Latin and Greek, 9711.

Assistant Professors, &c.
Assistant wanted for natural philosophy at St. Andrew's University; 12*l.* only allowed, 9708, 9725, 9737.
Universities' Act provided for assistants in some Scotch Universities, but not in St. Andrew's, 9729–9735.

Chemistry.
Deficient allowance for chemistry class expenses at St. Andrew's University; 100*l.* a year requisite, 9748–9751.

Colleges.
Formerly three colleges at St. Andrew's University; now two, Mary's and United Colleges, 9716–9719.

Degrees.
For St. Andrew's degree in arts, students remain four years, except they undergo entrance examination in Latin and Greek, 9711.

Dundee.
Approval of scientific instruction at Dundee in connexion with St. Andrew's University, 9743–9747, 9752–9757.
For artizans, &c., evening lectures in Dundee will be essential, 9745.

Edinburgh University.
Provision made for assistants, class expenses, &c., in Edinburgh University, 9729–9733.

Evening Instruction.
Evening lectures for artizans, &c. will have to be given in Dundee, 9743–9747, 9752–9757.

Examinations.
Examinations in natural philosophy at St. Andrew's University are oral and written, 9706, 9739.
St. Andrew's University students stay four years for arts' degree, unless they pass an entrance examination in Latin and Greek, 9711.

Glasgow University.
Provision made for assistants, class expenses, &c. at Glasgow University, 9727–9733.

Government.
For extension of St. Andrew's University, Government grant is requisite, 9716–9719.

Greek and Latin.
Preliminary examination in Greek and Latin enables St. Andrew's University students to obtain arts' degree after three years, 9711.

Swan, Prof.—cont.

Income and Expenditure.
Government grant essential for extension of St. Andrew's University, 9718.
Funds of natural philosophy chair at St. Andrew's; salary, fees, &c. estimated at 448*l.* 15*s.*; 52*l.* 10*s.* only allowed for class expenses, 9720–9728.
College revenues at St. Andrew's University could not be applied otherwise than as at present, 9720–9722.
No provision made by Scotch Universities' Act for application of public money to teaching natural science, 9731, 9732.
100*l.* a year for class expenses (exclusive of laboratory) should be provided by St. Andrew's University, 9748–9751, 9758.

Laboratories.
No physical laboratories in St. Andrew's University; much wanted; one might be constructed behind present buildings, 9718, 9740–9742.

Latin. See *Greek and Latin.*

Lectures.
Lectures on natural philosophy at St. Andrew's University, 9706–9709.
Scientific lectures in Dundee should be given in connexion with St. Andrew's, with evening lectures for artizans, &c., 9743–9747, 9752–9757.

Mathematics.
In St. Andrew's University natural philosophy course, four hours weekly are given to applied mathematics, 9709.

Natural Philosophy.
Natural philosophy course at St. Andrew's University; it comprehends applied mathematics and experimental physics, 9705–9758.
Natural philosophy chair at St. Andrew's has 448*l.* 15*s.* a year; 52*l.* 10*s.* for expenses; 100*l.* required, 9720–9728, 9748–9751, 9758.

Parliament.
Act of Parliament requisite to alter distribution of college revenues at St. Andrew's University, 9720–9722.
Scottish Universities' Act did not provide for application of public money to science classes, 9731, 9732.

Physics.
St. Andrew's University natural philosophy course; three hours weekly given to experimental physics, 9709.

Professors.
Professor of natural philosophy at St. Andrew's University; lectures seven times a week; has no assistant, 9705–9709, 9720–9728.
Professors of St. Andrew's University could not be available in Dundee, 9743–9747.
St. Andrew's University professors should have 100*l.* a year for class expenses, 9748–9751, 9758.

Professorships.
Chair of natural philosophy at St. Andrew's University; its teaching, emoluments, &c., 9705–9758.

Saint Andrew's University.
Scientific instruction in St. Andrew's University, 9705–9758.
See *Professors, Students, &c.*

Science.
Promotion of science in St. Andrew's University, 9705–9758.
Grants for natural science in certain Scotch Universities made by Universities' Act, 9729–9735.

Scotland.
Universities of Scotland afford great facilities to poor students, 9713.

Scottish Universities. See *Universities.*

Students.
Students in natural philosophy department at St. Andrew's University; generally under 20 years of age, 9706–9713, 9725.
St. Andrew's University students remain four years for arts' degree, except they undergo preliminary examination in Latin and Greek, 9711.
Scottish university system greatly benefits poor students, 9713.
Dundee students may come to St. Andrews, but for artizans there must be lectures in Dundee, 9743–9747, 9752–9757.

Swan, Prof.—cont.

- *Universities.*
  - Scottish universities offer great advantages to poor students, 9713.
  - Universities of Edinburgh, Glasgow, and Aberdeen (but not St. Andrew's) were allowed grants for science by the Act, 9729–9735.
- *Universities Act (Scotland).*
  - Distinction between St. Andrew's and other Universities in Scotland, as to provision of assistants, &c., made by Universities' Act, 9729–9735.
  - Scotch Universities' Act did not provide grants of public money in aid of natural science teaching, 9731, 9732.

HEDDLE, Professor M. FORSTER, M.D. (Index of his Evidence.)

- *Accommodation for Science Purposes.*
  - Chemical department at St. Andrew's University needs a laboratory and practical class-room, 9765, 9766, 9786.
- *Age of Students.*
  - Medical degree for candidates over 40 years of age at St. Andrew's University, 9787.
- *Anatomy and Physiology.*
  - Efficient condition of St. Andrew's University chair of anatomy and physiology; advantage of instruction in hygiene, 9788.
- *Apparatus for Science Purposes.*
  - Insufficient grant for chemical illustration at St. Andrew's; 100*l*. a year wanted, 9761, 9772–9780.
  - Obstructions to chemical lecturing in Scotland, through want of apparatus, 9770, 9771.
  - For chemical apparatus, &c. Edinburgh University allows 300*l*., Aberdeen 270*l*., and Glasgow 260*l*., 9773.
- *Assistant Professors.*
  - No assistant for chemistry at St. Andrew's University; 80*l*. should be allowed for this, 9768, 9780.
- *Chemistry.*
  - Chemical instruction at St. Andrew's University; want of laboratory, &c.; diminished value of chair, 9759–9790.
  - At St. Andrew's University, chemical lectures must be attended for a degree, 9763.
  - Want of chemical instruction in schools is a drawback to teaching at St. Andrew's University, 9764.
  - Demand for chemical teaching in Dundee, Cupar, &c., 9770, 9771.
- *Cupar.*
  - Desire for chemical instruction in Cupar; lectures now given there, 9771.
- *Degree.*
  - Chemical lectures at St. Andrew's University must be attended for a degree, 9763.
  - Ten medical degrees only given by St. Andrew's University, 9787.
- *Dundee.*
  - Demand for chemical instruction in Dundee, 9770, 9771.
  - New institution at Dundee should be affiliated to St. Andrew's, 9781–9784.
- *Edinburgh University.*
  - 300*l*. is the allowance for chemical apparatus, &c. at Edinburgh University, 9773.
- *Examinations.*
  - Eight to 12 written examinations in chemistry annually at St. Andrew's University, 9786.
  - Medical examinations of St. Andrew's formerly chief source of income of professor of chemistry, 9787.
- *Glasgow University.*
  - 260*l*. is the allowance for chemical apparatus at Glasgow University, 9773.
- *Government.*
  - Government grants for professors of chemistry and natural history at St. Andrew's University, 9761–9790.
- *Hygiene.*
  - Advantage of the instruction in hygiene at St. Andrew's University, 9788.

Heddle, Prof.—cont.

- *Income and Expenditure.*
  - Chair of chemistry at St. Andrew's University; formerly worth 500*l*. now 200*l*., 9759–9761, 9772, 9780, 9787.
  - Surplus funds of St. Andrew's University properly go towards the library, 9768, 9769.
  - 80*l*. for an assistant, 100*l*. to 120*l*. for apparatus and higher fees, wanted at chemical department of St. Andrew's University, 9780, 9785.
  - Revenue of St. Andrew's University is diminishing, 9787.
  - Endowment of chair of natural history at St. Andrew's is about 300*l*., 9789, 9790.
- *Laboratory.*
  - Want of a chemical laboratory at St. Andrew's University, 9765.
- *Library.*
  - Surplus funds of St. Andrew's University are properly appropriated at present to library, 9768, 9769.
- *Medicine.*
  - Restriction of medical degrees at St. Andrew's University, 9787.
  - Emoluments of chair of chemistry at St. Andrew's University were formerly chiefly from medical examinations, 9787.
  - A medical faculty, but no medical school, in St. Andrew's University, 9788.
- *Museums.*
  - Good museum for teaching purposes at St. Andrew's University; funds requisite, 9788.
- *Natural History.*
  - Advantage of position of St. Andrew's for natural history teaching, 9788.
  - Natural history chair at St. Andrew's will come to be an important one, if museum be extended; endowment is now about 300*l*., 9788–9790.
- *Original Research.*
  - St. Andrew's University professor of chemistry has scarcely any time for original research, 9777.
- *Practical Instruction.*
  - Want of a class-room for teaching practical chemistry at St. Andrew's University, 9765.
- *Physiology.* See *Anatomy and Physiology.*
- *Professors.*
  - Professor of chemistry at St. Andrew's University; his income; he has scarcely any time for research, 9759–9777, 9786, 9787.
  - Difficulty in St. Andrew's professors going to teach in Dundee; they might teach solely there, 9781–9784.
  - Professor of natural history at St. Andrew's University has about 300*l*. a year, 9788–9790.
  - Efficient teaching of St. Andrew's professor of anatomy and physiology, 9788.
- *Professorships.*
  - Chair of chemistry at St. Andrew's University, 9759–9790.
- *Saint Andrew's University.*
  - Instruction in chemistry, &c. at St. Andrew's University, 9759–9790.
    - See *Professors, Students, &c.*
- *Schools.*
  - St. Andrew's University suffers from the want of chemical instruction in schools, 9763.
  - School of science, affiliated to St. Andrew's, desirable at Dundee, 9781–9784.
- *Science.*
  - Chemical science at St. Andrew's University, 9759–9790.
- *Scotland.*
  - In Scotland there are universities enough, 9784.
- *Students.*
  - St. Andrew's University students of chemistry; about 30; must attend chemistry for a degree, 9762–9764.
  - Ten medical degrees to candidates over 40 years of age given at St. Andrew's University, 9787.
  - Advantage of the instruction in hygiene to St. Andrew's students, 9788.
- *Universities.*
  - There are enough universities in Scotland, 9784.

University of Dublin.

JELLETT, Rev. JOHN HEWITT, B.D. (Index of his Evidence.)

Accommodation for Science Purposes.
Laboratories for working chemists, &c. at Dublin University; physical laboratory proposed, 12,763–12,775, 12,787–12,791.

Astronomy. See *Observatories.*

Belfast. See *Scientific Societies.*

Chemistry.
Chemical instruction at Dublin University; two important laboratories, 12,763, 12,767.

Classics. See *Literature.*

Council of Scientific Advice.
State council for science desirable; large body not essential; the work could be done by detailed reports; Irishmen must be on the council, 12,805–12,817.

Degrees.
Dublin University degree in arts may be obtained without attending lectures, 12,735–12,738.

Dublin University.
Promotion of science in Dublin University, 12,729–12,791.

Examinations.
At Dublin University lectures can be substituted for examinations, 12,730–12,743.
Original workers have mostly been successful candidates at examinations, 12,760–12,762.

Fellowships.
Dublin University fellowships; best obtained through mathematics and classics; fellows are all teachers, 12,750–12,753, 12,759.

Government.
Government should have the aid of a scientific council, 12,805–12,817.

Grants for Science Purposes.
Royal Irish Academy and Royal Dublin Society (but not Dublin University) receive State grants, 12,781, 12,787–12,801.

Income and Expenditure.
Revenues of Dublin University; controlled by visitors; not aided by Government; appropriated to publications, museums, &c., 12,776–12,783, 12,787–12,791.

Ireland.
In a State scientific council, Ireland would have to be represented, 12,816.
See *Belfast, Dublin, &c.*

Laboratories.
Important chemical laboratories at Dublin University; physical laboratory contemplated, 12,763, 12,767, 12,774, 12,775, 12,787–12,791.

Lectures.
Lectures at Dublin University; professors' lectures are for higher students; lectures can be substituted for examinations, 12,730–12,743.

Literature.
Dublin University third and fourth year's students can dispense with classics, and take up science, 12,740–12,752.
High place in classics favourable to attainment of fellowships at Dublin University, 12,750–12,753.

Mathematics.
Mathematics and mathematical physics compulsory for all students at Dublin University; high place in mathematics favourable to attainment of fellowships, 12,744–12,753.

Meteorology. See *Observatories.*

Observatories.
Observatories for astronomy, meteorology, &c. at Dublin University; results published, 12,763, 12,767–12,774.

Original Research.
Dublin University liberally aids original research, 12,754–12,759, 12,782.
Men distinguished for research have mostly succeeded in passing examinations, 12,760–12,762.
Royal Irish Academy receives and publishes original research, 12,792–12,804.

Physics.
Physical instruction at Dublin University; experimental physics largely introduced; laboratory proposed, 12,746–12,752, 12,774, 12,775, 12,787–12,791.

Jellett, Rev. J. H.—cont.

Professors.
Dublin University professors; teach the higher students; elected by provost and senior fellows, 12,730–12,738, 12,763–12,786.

Professorships.
Scientific professorships at Dublin University; new ones founded, and others reorganized, 12,730–12,738, 12,763–12,786.

Royal Dublin Society.
Royal Dublin Society is a scientific body; it is aided by Government, 12,819, 12,820.

Royal Irish Academy.
Royal Irish Academy is aided by Government; it publishes scientific researches, 12,792–12,804.

Scholarships.
Many scholarships in Dublin University; none specially for experimental physics, 12,756–12,758.

Science.
Promotion of science in University of Dublin, &c., 12,729–12,820.

Scientific Publications.
Dublin University publishes astronomical results, &c., 12,767–12,774, 12,782.
Royal Irish Academy publishes researches, with aid of Government, 12,792–12,804.

Scientific Societies.
In Belfast there is a scientific society, 12,818.
Royal Dublin Society is a scientific institution; it is aided by Government, 12,819, 12,820.

Students.
Dublin University students; they have a definite course for the first two years, and can take up science in the third year, 12,730–12,753.

Tutorial Instruction.
Tutorial instruction in Dublin University; more catechetical than professors' teaching, 12,730–12,734.

LESLIE, Rev. JOHN R., M.A. (Index of his Evidence.)

Arts.
At Dublin University a degree in arts must precede a medical and engineering degree, 12,841, 12,880, 12,881.
Chemistry and geology are optional subjects in Dublin University arts' course, 12,852.
175 degrees in arts granted annually by Dublin University, 12,887.

Chemistry.
Chemical instruction at Dublin University; three laboratories; chemistry an optional subject in arts' course, 12,831–12,836, 12,852.

Degrees.
Dublin University arts' degrees; 175 granted annually; must precede medical and engineering degrees, 12,841, 12,887.
Dublin University bachelorship of engineering; three years' practical work essential for complete degree, 12,842–12,849, 12,880, 12,881.

Dublin University.
Promotion of experimental philosophy, &c. at Dublin University, 12,821–12,888.
See *Engineering, &c.*

Engineering.
Dublin University instruction for engineers; degree given; museum of engineering models, &c., 12,831–12,852, 12,858–12,863, 12,880, 12,881.
Establishment of Cooper's Hill Engineering College not needed, 12,864–12,879.

Examinations.
Dublin University examinations; attendance on lectures in physics counts in lieu of examination; examination for engineering degree, 12,824, 12,840–12,845.
Competitive examinations for engineering students, &c. should be followed by responsible practical work, 12,869–12,879.

Fellowships.
Dublin University fellowships depend mainly on classics or mathematics; difficult to alter this, 12,852–12,857.

France.
Objection to French system of sending engineering students merely to look at works, 12,876.

Leslie, Rev. J. R.—cont.

Geology.
Geology at Dublin University; museum fairly complete; geology an optional subject in arts' course, 12,828–12,830, 12,852.

Indian Civil Engineering College (Cooper's Hill).
Instruction at Trinity College, Dublin, is equal to that given in Cooper's Hill College; no reason for establishment of the latter, 12,864–12,879.

Laboratory.
Dublin University laboratories for practical chemistry; special laboratory for medical and engineering students, 12,831–12,836.

Lectures.
Lectures on physics at Dublin University; attendance on lectures counts in lieu of examinations, 12,821–12,824.

Literature.
Fellowships of Dublin University depend on classics or mathematics, 12,855.

Mathematics.
Dublin University fellowships depend on mathematics or classics, 12,855.

Medicine.
Instruction in practical chemistry connected with medicine at Dublin University; arts' degree must precede medical, 12,831–12,836, 12,880, 12,881.

Mineralogy.
Dublin University museum of mineralogy is fairly complete, 12,828–12,830.

Museums.
Museums at Dublin University; museum of natural philosophy apparatus added to daily; good museum of geology and mineralogy, 12,825–12,830, 12,861–12,863.

Physics.
Instruction in physics at Dublin University; physics do not tell much in examinations for fellowships, 12,821–12,827, 12,838, 12,852–12,857.
Importance to physical teaching of accurate quantitative experiments; provision for this wanted, 12,882.
Study of physics opens no special career to students, 12,884.

Practical Instruction.
Instruction in practical chemistry given to medical students, &c. at Dublin University, 12,831–12,836.
Practical engineering instruction of Dublin University students; three years' practical work essential for full degree, 12,842–12,849, 12,880, 12,881.
Engineers for the public service, after competitive examination, should be sent out on practical works, 12,869–12,879.

Scholarships. See *Fellowships and Scholarships.*

Science.
Teaching of experimental philosophy, &c. at Dublin University, 12,821–12,888.

Students.
Dublin University students; 130 attend physics' course; special instruction for engineers; no special career open to students of physics, 12,823–12,888.

MACALISTER, ALEXANDER, Esq., M.B. (Index of his Evidence.)

Anatomy.
Anatomical instruction at Dublin University; professor appointed septennially; lectures open to art as well as medical students; museum under professor, 12,897, 12,898, 12,905–12,935.

Assistant Professors, &c.
Dublin University professor of anatomy is assisted by University anatomist and demonstrators, 12,916–12,920.

British Museum.
British Museum might aid Dublin University Zoological Museum with duplicate specimens, 12,939*a*–12,940.

Chemistry.
At Dublin University, chemistry is an optional subject for ordinary degrees, but essential in medical courts, 12,957, 12,958.

Degrees.
Dublin University degrees; examinations are written and vivâ voce, 12,921, 12,957, 12,958.

Macalister, A., Esq.—cont.

Dublin. See *Royal Dublin Society, Zoological Gardens, &c.*

Dublin University.
Natural science teaching at Dublin University, 12,889–12,960.
See *Professors, &c.*

Examinations.
Dublin University examinations; natural science examination for moderatorship; examiners are connected with University; examinations for degree are written and vivâ voce, 12,893, 12,899–12,902, 12,919–12,928, 12,955, 12,956.

Fellowships and Scholarships.
Natural science subjects are but little considered in conferring fellowships and scholarships at Dublin University, 12,894, 12,896.

Geological Society of Ireland.
Connexion between Dublin University and Geological Society of Ireland; geological museum first given by the society, 12,954.

Income.
Emoluments of professorships of anatomy at Dublin University; about 1,200*l.* a year, 12,909–12,913.
Dublin University Zoological Museum has a grant of 100*l.* a year for specimens, &c., 12,937.

Lectures.
Dublin University lectures; geology and zoology can be taken in place of classical lectures; in winter medical course each professor gives 56 lectures, 12,893, 12,904.

Literature.
At Dublin University, geology and zoology lectures may be taken in place of classical lectures, 12,893.

Medicine.
Medical instruction at Dublin University; over 200 students attend; examinations written and vivâ voce; chemistry essential in medical course, 12,895–12,897, 12,903, 12,904, 12,909–12,958.
Institutes of Medicine examination at Dublin University; conducted by professor; by writing only, 12,923–12,926.

Moderatorships.
Moderatorship in natural science at Dublin University, 12,893.

Museums.
Museum of anatomy at Dublin University; space small distinct museum of zoology, which might be aided by British Museum, 12,930–12,940.
Royal Dublin Society has a large public museum of zoology, geology, and ethnology, 12,941–12,943, 12,959.
See *British Museum.*

Practical Instruction.
Dissecting rooms in Dublin University; superintended by professor of anatomy, University anatomist, and demonstrators, 12,909–12,921.

Professors.
Professors at Dublin University; four for natural science, 12,889–12,960.

Professorships.
Professorships at Dublin University; they are mostly held for a limited time, 12,889–12,959.

Royal Dublin Society.
Royal Dublin Society has a large museum of zoology, geology, and ethnology, 12,941–12,943, 12,959.

Scholarships. See *Fellowships and Scholarships.*

Science.
Promotion of natural science at Dublin University, 12,889–12,960.

Students.
Dublin University students of natural science; few in number; their inducements are few; over 20 medical students, 12,893–12,896, 12,903.

Zoology.
Zoological instruction at Dublin University; professor gives two courses annually; distinct museum of zoology, 12,890–12,893, 12,936–12,941, 12,955, 12,956.
Royal Dublin Society has a large museum of zoology, &c., 12,941–12,943.

Zoological Gardens (Dublin).
Zoological Gardens, Dublin; supply specimens to University of Dublin; large number of members, 12,944–12,953.

Queen's University in Ireland.

TOWNSEND, EDWARD, Esq., M.A. (Index of his Evidence.)

Age of Science Students.

Students of Queen's College, Galway, obtain degrees at 20 or 21 years of age, 13,147.

Botany.

Botanical instruction at Queen's College, Galway; flowers provided; students make excursions, 13,156.

Chemistry.

Chemical instruction at Queen's College, Galway; lectures and laboratory teaching; moderate fees, 13,153, 13,154.

Degrees.

Degree of Bachelor of Engineering granted by Queen's College, Galway, 13,140, 13,147.

Engineering.

Engineering instruction at Queen's College, Galway; course comprises three years; examinations; degrees; scholarships, 13,138–13,169.

Examinations.

Engineering students of Queen's College, Galway, have university, college, and scholarship examinations, 13,139–13,142, 13,150.

Objection to the examination system at Cooper's Hill College, 13,158–13,164.

Exhibitions. See *Scholarships and Exhibitions.*

Geology.

Instruction in geology and mineralogy at Queen's College, Galway; good illustrative museum; practical fieldwork done, 13,155.

Income and Expenditure.

Engineering students' fees at Queen's College, Galway, average 10 guineas, 13,145.

Objection to the 40*l.* fee at Cooper's Hill College, 13,159.

Indian Civil Engineering College, Cooper's Hill.

Objection to Cooper's Hill College; hardship of students from Ireland, &c. having to pass an entrance examination at the college; objection to the 40*l.* fee, 13,158-13,164.

Laboratory.

Queen's College, Galway, has an adequate chemical laboratory, 13,153, 13,154.

Mineralogy. See *Geology.*

Museums.

Good museums for zoology, palæontology, &c. at Queen's College, Galway, 13,155, 13,156.

Natural History.

Natural history instruction at Queen's College, Galway, 13,156.

Practical Instruction.

Engineering students at Queen's College, Galway, have practical instruction, but they require to go into an engineer's office, 13,139, 13,146.

Practical instruction in chemistry, geology, and botany is given at Queen's College, Galway, 13,153–13,156.

Queen's College, Galway.

Engineering instruction, &c. at Queen's College, Galway, 13,138-13,169.

Scholarships and Exhibitions.

Queen's College, Galway, offers five scholarships in engineering, worth 20*l.* each, tenable for a year; also two Peel exhibitions of 40*l.* and 30*l.* value, 13,139–13,144.

Science.

Instruction in engineering science, &c. at Queen's College, Galway, 13,138–13,169.

Students.

Students of engineering, &c. at Queen's College, Galway; average number, 16; enter engineer's office after taking university diploma; they mostly study for Indian appointments, 13,138–13,169.

Hardship of Cooper's Hill College examination system for students from Ireland, &c., 13,158–13,164.

Special disabilities of engineering students preparing for Government employment, 13,164.

Zoology.

Zoological instruction at Queen's College, Galway; good illustrative museum, 13,156.

CURTIS, ARTHUR HILL, Esq., LL.D (Index of his Evidence.)

Arts.

Arts' students at Queen's College, Galway; third year's men may select honour class of mixed mathematics or experimental physics, or both, 13,177.

Candidates for medical degree in Queen's College, Galway, need not have taken arts' degree previously, 13,186.

Degrees.

Dublin University degrees; one for doctor of science, one for bachelor of science; honours in experimental physics alone not sufficient for a degree, 13,177–13,191.

Dublin University.

Professors of Queen's College, Galway, are also professors and examiners in Dublin University, 13,170–13,176.

Engineering.

Engineering instruction at Queen's College, Galway; courses in mixed mathematics and experimental physics, 13,177, 13,180, 13,181.

Examinations.

Examinations at Queen's College, Galway; one examination annually after each separate course, 13,174–13,178.

Professors of Queen's College, Galway, conduct Dublin University examinations, 13,170–13,176.

Mathematics.

Instruction in mixed mathematics at Queen's College, Galway, 13,177, 13,192.

Medicine.

Medical students at Queen's College, Galway; large number; education extends over four years, 13,177–13,188.

Medical degree need not be preceded by arts' degree at Queen's College, Galway 13,186.

Natural Philosophy.

Instruction in natural philosophy at Queen's College, Galway, 13,170–13,198.

Professors.

Professors of Queen's College, Galway; they are mostly professors both in the college and in Dublin University, 13,170–13,176.

Queen's College, Galway.

Instruction in mathematics, physics, &c. at Queen's College, Galway, 13,177–13,198.

Scholarships.

Ten junior scholarships for science and classics at Queen's College, Galway, 13,177, 13,196.

Science.

Natural philosophy instruction at Queen's College, Galway, 13,170–13,198.

Students.

Students of natural philosophy at Queen's College, Galway; arts, medical, and engineering students obliged to attend; great number, 13,177–13,198.

KANE, Sir ROBERT, LL.D., F.R.S. (Index of his Evidence.)

Age of Students.

Students of Queen's College, Cork, matriculate at 16 or 17 years of age; medical students at about 17 years, 13,225.

Apparatus for Science Purposes.

Want of funds for scientific apparatus at Queen's College, Cork; natural history apparatus satisfactory, 13,201, 13,202, 13,226.

Appointments.

Government appoints professors at Queen's College, Cork; it always selects the best men, 13,232.

Assistant Professors.

Want of assistant professors at Queen's College, Cork, 13,217–13,219.

Botany.

Botanical instruction at Queen's College, Cork; excellent herbarium; conservatory wanted, 13,201, 13,202.

Chemistry.

Good teaching of practical chemistry at Queen's College, Cork, 13,217–13,220.

Classics.

Engineering students at Queen's College, Cork, are relieved from classics, 13,224, 13,225.

KANE, Sir R.—cont.

Cork. See *Queen's College, Cork.*

Degrees.
Queen's University at Dublin conducts its own examinations for degrees, 13,207.
For medical degrees of Queen's University, practical chemistry is essential, 13,220.

Education.
Imperfect preliminary education of Irish students through want of middle-class schools, 13,201.

Engineering.
In matriculation examination at Queen's College, Cork, engineering students are relieved from classics, 13,221–13,225.

Examinations.
Defective education of students shown by entrance examination at Queen's College, Cork, 13,201, 13,204.
Matriculation examination essential for students of Queen's College, Cork, 13,201, 13,204, 13,221–13,225.
Degree examinations of Queen's University, Ireland, are held in the University; entrance and class examinations in the Colleges, 13,207.
Examinations (except medical) of Queen's University and Colleges, Ireland, are conducted by professors; system has worked well, 13,213.
Greek essential for examinations at Queen's College, Cork, except for engineering students, 13,221–13,225.

Greek.
Necessity for Greek at Queen's College, Cork, except in engineering department, 13,221–13,225.

Ireland.
Want of secondary school instruction in Ireland, 13,201.

Laboratories.
Excellent chemical laboratory at Queen's College, Cork, 13,217–13,219.
Laboratory instruction in chemistry essential for medical degree in Queen's University, Ireland, 13,220.

Lectures.
69 lectures on zoology and botany, and 74 on geology and mineralogy, given at Queen's College, Cork, in 1870–1, 13,201, 13,202.

Libraries.
Funds wanted for keeping up library at Queen's College, Cork, 13,226–13,229.

Mathematics.
Want of preliminary mathematical training shown by students who enter Queen's College, Cork, 13,201.

Matriculation.
Matriculation examination for students of Queen's College, Cork, 13,201, 13,204, 13,221–13,225.

Medicine.
More than half the students of Queen's College, Cork, are medical students, 13,202, 13,203.
Want of a professor of medical jurisprudence in each of the Queen's Colleges, Ireland, 13,215, 13,216.
Practical chemistry essential for medical degree of Queen's College, Ireland, 13,220.

Museums.
Good museum for zoology and botany at Queen's College, Cork, 13,201.

Natural History
At Queen's College, Cork, 69 lectures and herborization are given in natural history; teaching apparatus satisfactory, 13,201, 13,202.

Original Research.
Difficulty of professors finding time for original research; assistants should be provided, 13,231.

Practical Instruction.
Good practical instruction in chemistry given at Queen's College, Cork, 13,217–13,219.
Herborizations given in natural history course at Queen's College, Cork, 13,201.

Professors.
Queen's College, Cork, has seven professors for science; they do a large amount of work; much of their teaching is elementary, 13,201.
Professors conduct all examinations, except medical, of Queen's University and Colleges in Ireland, 13,213.
Special professor of medical jurisprudence should be added to each of the Queen's Colleges in Ireland, 13,215, 13,216.
Professors have little time for research; they should have assistants, 13,231.
At Queen's College, Cork, professors are appointed by Government; best men always selected, 13,232

KANE, Sir R.—cont.

Queen's College, Cork.
Promotion of science at Queen's College, Cork, 13,200–13,230.
See *Professors, Students, &c.*

Queen's University, Ireland.
Queen's University, Ireland, is a teaching university; it directs instruction in the Colleges, 13,204–13,206.

Scholarships and Exhibitions.
Queen's College, Cork, has 54 scholarships, of 20*l.* to 40*l.*; also Peel exhibitions, 13,209–13,215.

Schools.
Want of secondary schools in Ireland, 13,201.

Science.
Promotion of science at Queen's College, Cork, 13,200–13,230.

Students.
Irish students, through want of secondary schools, enter colleges ill prepared, 13,201.
Medical students at Queen's College, Cork; these form more than one half, 13,202, 13,203, 13,208, 13,220.
All students of Queen's College, Cork, have to pass the matriculation examination, 13,221–13,225.

Zoology.
Zoological courses at Queen's College, Cork; good illustrative museum, 13,201, 13,202.

ENGLAND, PROFESSOR JOHN, M.A. (Index of his Evidence.)

Apparatus for Science Purposes.
Defective physical apparatus at Queen's College, Cork, 13,237.

Cork. See *Queen's College, Cork.*

Engineering.
Engineering students at Queen's College, Cork, have instruction for three years, and then go into an engineering office, 13,234–13,247.

India.
Many students of Queen's College, Cork, have obtained appointments in India, 13,247.

Mathematics.
Mathematical instruction at Queen's College, Cork; professor's teaching is confined to pure mathematics, 13,234, 13,235, 13,244.

Natural Philosophy
Natural philosophy instruction at Queen's College, Cork; five courses of lectures; defective apparatus, 13,233–13,237, 13,244.

Practical Instruction.
Engineering students at Queen's College, Cork, after completing their instruction, go into an engineering office, 13,245, 13,246.

Professors.
Professor of natural philosophy at Queen's College, Cork, gives five courses; he has no assistant, 13,233–13,237, 13,244.

Queen's College, Cork.
Promotion of science at Queen's College, Cork, 13,233–13,247.
See *Students, &c*

Scholarships.
Students of Queen's Colleges at Cork, Belfast, or Galway may compete for scholarships at either place, 13,240.

Science.
Promotion of science at Queen's College, Cork, 13,233–13,247.

Students.
Students of Queen's College, Cork; many have become distinguished, and taken valuable appointments, 13,234–13,247.

PURSER, PROFESSOR JOHN, M.A (Index of his Evidence.)

Accommodation for Science Purposes.
Queen's College, Belfast, has room for a much-needed physical laboratory, 13,281, 13,282, 13,288, 13,289.

Apparatus for Science Purposes.
Queen's College, Belfast, has good chemical but bad physical apparatus, 13,307, 13,308.

Assistant Professors.
Assistant professors for mathematics and natural philosophy wanted at Queen's College, Belfast, 13,256, 13,281.

Purser, Prof.—cont.

Belfast.
Belfast Academical Institution, now the high school; the best feeder of Queen's College, 13,284, 13,285.
See *Queen's College, Belfast.*

Chemistry.
Chemical instruction at Queen's College, Belfast; large number in laboratory; apparatus good, if maintained, 13,270–13,274, 13,286, 13,287, 13,307.

Endowments.
Endowment scholarships at Queen's College, Belfast, founded by Dr. Sullivan and Mr. Porter, 13,275–13,279, 13,283.

Engineering.
Remarks by Prof. Jas. Thomson on Engineering Department of Queen's College, Belfast, 13,266.
Practice in an engineer's office is essential for engineering students leaving Queen's College, Belfast, 13,266.
Engineering students have to attend chemistry at Queen's College, Belfast, 13,272.

Examinations.
Special examinations for private endowment scholarships at Queen's College, Belfast, 13,275–13,279.

Faculties.
Students of Queen's College, Belfast, are divided into four faculties, 13,254.

Geology.
Geology and natural history chair amalgamated at Queen's College, Belfast, 13,252.

Income and Expenditure.
Queen's College, Belfast, has 1,100*l.* a year only for maintenance; funds needed; fees (except 5*s.*) go to professors, 13,280, 13,281, 13,294–13,309, 13,314.

Laboratories.
Large number of pupils in chemical laboratory of Queen's College, Belfast, 13,270.
Physical laboratory wanted at Queen's College, Belfast, 13,281, 13,282.

Libraries.
Want of funds for library of Queen's College, Belfast, 13,280, 13,281–13,292.

Mathematics.
Mathematical instruction at Queen's College, Belfast; difficulties of professor, whose senior scholars assist him; permanent assistant needed, 13,256–13,269.
Eager competition for scholarships in pure mathematics at Queen's College, Belfast, 13,256.

Medicine.
Medical course at Queen's College, Belfast, extends over four sessions, 13,263.

Natural History.
Natural history and geology chair amalgamated at Queen's College, Belfast, 13,252.

Natural Philosophy.
Assistant, laboratory, and apparatus wanted for natural philosophy department of Queen's College, Belfast, 13,281, 13,288, 13,289, 13,308.

Original Research.
Natural philosophy professor at Queen's College, Belfast, should have more time for research, 13,281, 13,288, 13,289.

Practical Instruction.
Engineering students, after leaving Queen's College, Belfast, require practical instruction, 13,266.

Professors.
Professors of Queen's College, Belfast; difficulties of mathematical professor, 13,256–13,269, 13,294–13,306.

Professorships.
Queen's College, Belfast, has amalgamated chairs of geology and natural history, 13,252.

Queen's College, Belfast.
Promotion of science at Queen's College, Belfast, 13,250–13,315.
See *Professors*, *Students*, *&c.*

Scholarships.
Scholarships for pure mathematics at Queen's College, Belfast, are eagerly competed for, 13,256.
Government scholarships at Queen's College, Belfast, same as at other Colleges; also private endowment scholarships, 13,275–13,279, 13,283.

Science.
Promotion of science at Queen's College, Belfast, 13,250–13,315.

Purser, Prof.—cont.

Students.
At Queen's College, Belfast, students are divided into four faculties, 13,254.
Varying attainments of students at Queen's College, Belfast, a hindrance to teaching, 13,256–13,259.
Senior students employed as assistants to mathematical professor at Queen's College, Belfast, 13,256, 13,257.
Engineering students of Queen's College, Belfast; they have practical instruction on leaving, 13,266–13,273.
Falling off in number of arts students at Queen's College, Belfast, 13,298–13,302.
Important posts gained by students of Queen's College, Belfast, 13,315.

Thomson, Prof. James.
Remarks by Prof. Jas. Thomson on the Engineering Department of Queen's College, Belfast, 13,266.

CUNNINGHAM, Professor ROBERT O., M.D.
(Index of his Evidence.)

Apparatus for Science Purposes.
Natural history apparatus at Queen's College, Belfast, defective from want of funds, 13,332, 13,342, 13,343, 13,357–13,360.

Assistant Professors.
Want of an assistant professor for natural history at Queen's College, Belfast, 13,331, 13,340, 13,360.

Belfast.
Belfast has a botanical garden, which furnishes plants to Queen's College, 13,330.
See *Queen's College, Belfast.*

Botany. See *Natural History.*

Engineering.
At Queen's College, Belfast, engineering students must attend geology course, 13,326.

Geology.
Natural history chair at Queen's College, Belfast (but not at Cork and Galway), includes geology; this subject should be separated, 13,316–13,347.
Engineering students at Queen's College, Belfast, must attend the course on geology, 13,326.

Income and Expenditure.
Income of professor of natural history at Queen's College, Belfast, is 300*l.* and 150*l.* fees; he has 50*l.* or 60*l.* for apparatus, which requires 100*l.*, 13,320–13,323, 13,332, 13,357–13,359.

Libraries.
Natural history library at Queen's College, Belfast, has a fair supply of students' books, but is wanting in works of a higher class, 13,333, 13,334.

Lectures.
Natural history course at Queen's College, Belfast, comprises 60 lectures in zoology, 50 in botany, and 40 in geology, 13,336.

Medicine.
Students of natural history course at Queen's College, Belfast, are two thirds medical students, 13,324.

Museums.
Natural history museum at Queen's College, Belfast, is directed by natural history professor; it has inadequate funds, 13,317, 13,329, 13,330, 13,357.

Natural History.
Chair of natural history at Queen's College, Belfast, comprises zoology, botany, and geology; the latter subject should be separated, 13,316–13,347.

Natural History Specimens.
Important fossils brought from Patagonia by Prof. Cunningham, and sent to Admiralty. 13,348–13,356.

Original Research.
Professor of natural history at Queen's College, Belfast, has no time for research, 13,347.

Practical Instruction.
Natural history professor at Queen's College, Belfast, can give little practical instruction; want of time, apparatus, &c., 13,338–13,344.

Professors.
Professor of natural history at Queen's College, Belfast, should be relieved of geology; he wants apparatus and assistants, and time for research, 13,316–13,360.

Professorships.
In Queen's College at Belfast (not at Cork or Galway) the natural history chair comprises geology, 13,316–13,347.

CUNNINGHAM, Prof.—cont.

Queen's College, Belfast.
Natural history science, &c. at Queen's College, Belfast, 13,316–13,360.
See *Professors, Students, &c.*

Science.
Promotion of natural history science at Queen's College, Belfast, 13,316–13,360.

CUNNINGHAM, Prof.—cont.

Students.
Students attending natural history course at Queen's College, Belfast, are two thirds medical; arts and engineering students also attend, 13,324–13,330.

Survey Expeditions.
Important fossils obtained in the Nassau Expedition, and sent to the Admiralty, 13,348–13,356.

Zoology. See *Natural History.*

Catholic University of Ireland.

LYONS, PROFESSOR ROBERT DYER, M.B. (Index of his Evidence.)

Accommodation for Science Purposes.
Catholic University of Ireland has museums, laboratories, &c., but for the extension required present buildings must be pulled down, 13,370, 13,375–13,385.

Catholic University of Ireland.
Catholic University of Ireland; founded in 1850; governed, under Episcopal Board, by rector and rectorial council, and by University senate; large contributions made to it by Catholics; it has library, museums, laboratories, &c.; it confers degrees in theology, 13,361–13,423.

Contributions for Science Purposes.
Large contributions of Catholics to Catholic University of Ireland, 13,369–13,372.

Degrees.
Degrees of Queen's University, Ireland; objection to them; students from Catholic University ineligible, 13,408, 13,413.
Catholic University of Ireland confers degrees in theology; it might confer them in other faculties, 13,414–13,417.
Like some Scotch universities, the Catholic University of Ireland grants degrees by virtue of a papal rescript, 13,414, 13,415.
Catholic University of Ireland should either grant degrees or be represented in a central examining body, 13,416, 13,417.

Dublin University.
Dublin University is of no advantage to students of Catholic University, 13,419.

Endowments.
Catholic University of Ireland should share endowments with other bodies; "endow all, or disendow all," 13,423.

Income and Expenditure.
Funds of Catholic University of Ireland; about 150,000*l.* contributed by Catholics; 700*l.* spent in scholarships this year, 13,369–13,378.

Ireland. See *Catholic University. Universities.*

Laboratories.
Part of Catholic University of Ireland is appropriated to laboratories, but considerable extension will be needed, 13,375–13,384.

Libraries.
Valuable scientific and medical library (the Ringseis Library) at Catholic University of Ireland, 13,375, 13,376.

Medicine.
Catholic University of Ireland possesses a separate building for the medical school, 13,380.
College of Physicians and College of Surgeons recognize teaching of Catholic College of Ireland, 13,420.

Museums.
Catholic University of Ireland has museums, which will require great extension, 13,369–13,381.

Original Research.
Catholic University of Ireland was founded to enable Catholics to pursue scientific research, &c.; histological observations conducted there, 13,386, 13,396.

Physiology.
First lectures in Ireland on the microscope and its uses in physiology, 13,386–13,388.

Professors.
Professors of Catholic University of Ireland are all Catholics; many are distinguished investigators; their position is one of great independence, 13,361, 13,386, 13,423.

LYONS, Prof.—cont.

Queen's University, Ireland.
Objection to conferring of degrees by Queen's University, as not providing for the higher education of students, 13,408–13,413.

Religion.
Catholic University of Ireland was established to enable Catholics to receive education and pursue scientific research; other students are admitted, and can obtain prizes; managers and professors are Catholics, 13,362–13,374, 13,396–13,423.
Degrees in theology only are granted by Catholic University of Ireland, 13,414–13,417.
Catholic University of Ireland, like some Scotch universities, derives its power of granting degrees from a papal rescript, 13,414.

Scholarships.
Want of science scholarships for Catholics before establishment of Catholic University of Ireland, 13,366.
Large contributions made for Catholic University of Ireland scholarships; these are not confined to Catholics, 13,371, 13,372, 13,396.

Science.
Science in Catholic University of Ireland; it has been promoted in every available manner, 13,361–13,423.

Scotland.
Several Scotch universities grant degrees by virtue of a papal rescript, 13,414.

Students.
Students of Catholic University of Ireland; attendance strictly enforced; chiefly Catholic, others being admitted; great number of medical students, 13,362–13,374, 13,389–13,396, 13,418–13,420.
Want of scholarships formerly for Catholic students in Ireland, 13,366.
Large body of students in Ireland qualified to take advantage of an institution like the Catholic University, 13,418.
Students of Catholic University of Ireland do not derive advantage from Dublin University, 13,419.

Universities
Some Scotch universities, like the Catholic University of Ireland, derive their power to grant degrees from a papal rescript, 13,414.
University institutions in Ireland have not the confidence of the public, 13,418.
A University Board might preside over all Irish universities, dispensing rewards, &c., each University college preserving its autonomy, 13,423.

SULLIVAN, WILLIAM KIRBY, ESQ., PH.D. (Index of his Evidence.)

Age of Students.
Students of Catholic University of Ireland enter at 17 or 18; none under 16 allowed, 13,435, 13,436.
In Irish secondary schools boys are retained from 7 to 21 years of age, 13,480.

Catholic University of Ireland.
Scientific instruction in the Catholic University of Ireland, 13,424–13,480.
See *Professors, Students, &c.*

Chemistry.
Chemical instruction at Catholic University of Ireland; practical teaching and examination, 13,428–13,432.

Degrees.
No Catholic University student (except medical) can obtain a Queen's University degree, 13,472–13,479.

Education.
Inappreciation of science and higher education in Ireland, 13,440, 13,444, 13,453–13,462.

SULLIVAN, W. K., Esq.—cont.

Examinations.
  Examinations at Catholic University of Ireland are written, vivâ voce, and practical; clear distinction between examiners and professors, 13,427, 13,428.
  Doubt of good results coming from competitive examinations, 13,445.
  Science cannot be advanced by examinations, especially in Ireland; a central examining council might remove some objections, 13,463–13,471.

Geology.
  At Catholic University of Ireland the teaching and examination in geology and mineralogy are practical, 13,428–13,431.

Income and Expenditure.
  Catholic University of Ireland funds; insufficient; poverty of students; fees moderate; professors paid from annual grants, 13,443–13,452.

Ireland.
  Impediments to scientific and higher education in Ireland, 13,440–13,462.
  Scientific examinations in Ireland would retard science, 13,463–13,471.
  Large number of middle and upper classes in Ireland never go to universities, 13,480.

Laboratory.
  Good chemical laboratory at Catholic University of Ireland; laboratory examinations held, 13,428, 13,437.

London University.
  London University is the only University open to students of Catholic University of Ireland, 13,479.

Medicine.
  Catholic medical students have obtained degrees in Queen's University after one session's attendance, 13,472–13,479.
  No Catholic University student can obtain a medical degree in Ireland, without going to some other institution, 13,478.

Mineralogy. See under *Geology.*

Museums.
  Good collection for teaching mineralogy and geology at Catholic University of Ireland, 13,438, 13,439.

Practical Instruction.
  Practical instruction in chemistry given at the Catholic University of Ireland, 13,428.

Professors.
  Professors at Catholic University of Ireland; they examine, associated with others; some have about 400*l.* stipend, 13,427, 13,449–13,452.

Professorships.
  Professorships at Catholic University of Ireland comprise higher mathematics, natural philosophy, chemistry, physiology, geology and architecture; also lecturer on botany, 13,426.

Queen's University, Ireland.
  Queen's University degrees not to be obtained by Catholic University students, except in medical faculty, 13,472–13,479.

Religion.
  Irish Catholics impeded in education; their poverty; mostly attend clerical schools only; degrees difficult for them to obtain, 13,440–13,462, 13,472–13,479.

Schools.
  Irish secondary schools; managed by clergy; scientific instruction wanting; boys stay till 21 years of age, 13,453–13,462, 13,480.
  Catholic University of Ireland has promoted scientific instruction in schools; it might provide teachers, 13,457, 13,458.

Science.
  Promotion of science in Catholic University of Ireland, 13,424–13,480.
  Science impeded in Ireland by ignorance, political situation, and want of funds, 13,443, 13,444.
  Want of science teaching in secondary schools of Ireland; Catholic University is remedying this, 13,453–13,462, 13,480.

Scientific Publications.
  Publication of "The Atlantis," at Catholic University of Ireland, 13,439–13,442.

Students.
  Students of Catholic University of Ireland; their difficulties, from poverty, &c.; aid might be granted them, 13,428–13,436, 13,443–13,448, 13,462, 13,472–13,479.

SULLIVAN, W. K., Esq.—*Students*—cont.
  Too great a tendency to pay students for learning, rather than for supplying means of teaching them, 13,446.
  Pupils in Irish secondary schools remain until 21 years of age, 13,480.

Teachers.
  Catholic University of Ireland might educate science teachers for Irish secondary schools, 13,457, 13,458.

Universities.
  Tendency of Irish students of superior classes to remain in schools, rather than go to universities, 13,480.

HENNESSY, HENRY, Esq., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
  Natural philosophy department at Catholic University of Ireland has not sufficient space for all its requirements, 13,490.

Apparatus for Science Purposes.
  Natural philosophy apparatus at Catholic University of Ireland is inadequate in parts, 13,488–13,490.

Assistant Professors.
  No assistant professors in faculty of science at Catholic University of Ireland, 13,505.

Catholic University of Ireland.
  Promotion of science at Catholic University of Ireland, 13,481–13,506.
    See *Professors, Students, &c.*

Civil Service Commission.
  Civil Service Commission rules should not be applied to experienced men of science, 13,492.

Cramming.
  A degree-giving body would foster cramming, 13,500.

Degrees.
  Desirable that Catholic University of Ireland should have power to grant degrees, 13,496–13,499.
  A body merely for giving degrees would be injurious to science, 13,500.

Examinations.
  Examinations in natural philosophy at Catholic University of Ireland are tutorial and official, 13,484.

Ireland.
  Educational disadvantages of Irish Catholics, 13,492.

Natural Philosophy.
  Natural philosophy at Catholic University of Ireland; every branch taught; impeded by want of a scientific career, 13,481–13,506.

Professors.
  Professors of natural philosophy, &c. at Catholic University of Ireland; they are enjoined to promote science through the press, 13,481–13,506.

Professorships.
  Difficulty of Catholics in obtaining professorships, 13,492.

Religion.
  Restricted career in science for Roman Catholics, 13,492.
  At Catholic University of Ireland no stringent profession of faith is required from professors, except for theology, 13,506.

Schools.
  Schools would be injuriously affected by a body instituted for giving degrees only, 13,500.

Science.
  Natural philosophy instruction at Catholic University of Ireland, 13,481–13,506.
  Experienced scientific men should not come under rules of Civil Service Commission, 13,492.
  Scientific career extremely restricted for Irish Catholics, 13,492–13,495.
  Science would be injured by a mere degree-giving body, 13,500.

Scientific Publications.
  Publication of "The Atlantis," &c. by professors of Catholic University of Ireland, 13,501–13,503, 13,506.

Students.
  Students of natural philosophy at Catholic University of Ireland; falling off of higher class, 13,484–13,487, 13,492–13,495.
  Want of a career in science an impediment to scientific students, 13,492–13,495.

Text-books.
  Text-books of natural philosophy used at Catholic University of Ireland are by Deschanel, Ganôt, and Pouillet, 13,491.

ANALYSES OF EVIDENCE

RESPECTING

THE ADVANCEMENT OF SCIENCE.

HENRY, Professor Joseph (Index of his Evidence.)

Agricultural Colleges.
Establishment of agricultural colleges in America; controlled by State governments; are doing good service to science, 1434, 1449–1452, 1535–1540.

Agricultural Department (Washington).
Reports on forest trees and agriculture, and distributes seeds and plants, &c., 1422, 1536.

America.
Primary schools and inspectors in America: supported and regulated by each separate State; scientific instruction probably given, though not necessarily required, 1428–1431, 1541, 1563–1565.
Higher schools in the cities of America; agricultural colleges, &c., 1434, 1449–1452, 1536–1539.
No national scholarships or examinations in science in the United States, 1435–1437, 1444.
Appropriations made by States of America for original scientific research,—geological and coast surveys, lighthouses, &c., 1438–1442, 1448, 1461–1465, 1542–1544.
Amount expended on science by United States governments, 1445, 1446.
Some American States support universities; the Government does not assist scientific societies, except in certain cases, 1447, 1448, 1470–1474.
American Government supports two important schools – Military Academy at West Point and Naval Academy at Annapolis; and has lately appointed a Minister of Education, 1453, 1454.
System of graded schools in certain States of America, 1456.
Scientific instruction at Harvard and Cornell Universities, 1458–1460.
American coast surveys develope a large amount of natural history knowledge, 1461–1464.
Professors, like those in the colleges of France, would be desirable in America, 1507–1509.
Importance of physical observations in the United States; physical cabinets in the States, 1517–1520.
Good effected by Agricultural Department at Washington, 1422, 1535.
Education in America renders people impatient of low manual labour, 1539.
Employment for engineers, chemists, &c. in America, 1555–1559.
A large number of Americans go to Germany, to study practical science, 1557.
New Haven and other schools in America endowed by individuals, 1560–1562.
See *Congress*; *Smithsonian Institution*.

Apparatus for Science Purposes.
Aid given by Smithsonian Institution to investigators, in the way of apparatus: laboratory and physical instruments in the institution before the fire, 1407, 1466, 1468, 1469, 1517, 1518, 1520.
Good supply of apparatus in science schools at Boston, Harvard, New York, &c., 1519.

Art.
Promotion of art by Smithsonian Institution, 1407.

Assistant Professors.
Approval, under restriction, of system of extra professors adopted in German universities, 1551.

Astronomy.
Aid to science of astronomy by Smithsonian Institution, 1407, 1419.

Bache, Professor.
Left his property for making original research, and publishing results, 1421.

Boston (U.S.)
There is a technological school at Boston, well supplied with apparatus, 1519.

Henry, Prof.—cont.

Botany.
Science of botany promoted by Smithsonian Institution; presentation of plants to agricultural department, &c., 1421, 1422.

Cambridge (U.S.)
The museum at Cambridge is supported by Massachusetts State and citizens, 1531–1534.

Chemists.
Many manufactories in United States; apt chemists not likely to want employment, 1559.

Coast Surveys.
Appropriations are made by the States of America for coast surveys; large amount of natural history knowledge obtained, 1442, 1461–1465.

Columbia College (New York).
Many American engineers, &c., have been educated in Columbia College; it is supported by donations of land given by the State of New York; the college supports the science school, which has good apparatus, 1519, 1558–1561.

Congress.
Relation of Congress to Smithsonian Institution; scientific information afforded to Congress by institution, 1407, 1411, 1469, 1566–1570.
Large grants of land made by Congress for establishment of agricultural colleges, 1434, 1449–1452.
Appropriations made by Congress for geological and coast surveys, lighthouses, &c., 1439–1444.
Military Academies at West Point and Annapolis supported by Congress, 1453.
Minister of Education lately appointed by Congress, to collect statistics and report upon the education of the various States, 1454.
In America, Government does not aid scientific societies, except in special cases; such aid should be given, 1470–1474.
Desirable that American Government should support professors similar to those in the colleges of France, 1509.
No aid given by American Government to National Academy, Philadelphia Academy, or Cambridge Museum, 1525–1534.
Surveys for railways, publication of voyages, &c. undertaken by American Government, 1542–1544.
See *America*.

Education.
In America, education has rendered people impatient of low manual labour, 1539.
A Minister of Education has been lately appointed by Congress, to collect statistics and report upon the education of the various States, 1454.

Elementary Schools.
American primary schools, and their inspection, are supported and regulated by each separate State, 1428–1431, 1565.

Endowments.
In America, some universities are supported by the State; most colleges by endowments from individuals; the latter are generally sectarian, the endowments having been raised by the church, 1447, 1560–1562.

Engineers.
Demand for engineers in United States; supply coming up to it, 1555–1557.
American engineers are educated abroad, or in the scientific schools of Harvard, Yale College, &c., 1558.

Ethnology.
Explorations, &c., to illustrate the ethnology of America, promoted by Smithsonian Institution, 1407, 1488, 1502.

HENRY, Prof.—cont.

Geological Surveys (*America*).
  In America, almost every State has made an appropriation for geological survey; the general government makes similar appropriations, 1438–1442.

Germany.
  The German system of professors might be advantageous in America, under restriction, 1554.
  A large number of Americans go to Germany, to study practical science, 1557.

Government. See *Congress.*

Government Grants in aid of Science.
  Small amount at disposal of Government Grant Committee of Royal Society; twenty times the sum might be expended, 1573, 1574.

Harvard University (*U.S.*)
  Thorough scientific training given at Harvard University, which has a scientific school, with good apparatus, attached to it; attendance at science classes is obligatory, 1458–1460, 1519, 1558.

Inspection.
  In America, primary schools in the different States are inspected by officers chosen by those States, 1428–1431.

Laboratories (*Physical*).
  The establishment of a physical cabinet is quite within the purpose of the Smithsonian Institution, which possessed a good one before the fire, 1468, 1517, 1518, 1520.
  Several of the United States science schools possess good physical cabinets, 1519.

Massachusetts.
  The State of Massachusetts, and individual subscribers, support the Cambridge Museum, 1531–1534.
  In Massachusetts, where education is most general, the people object to low manual labour, 1539.

Mathematics.
  Aid to mathematical science given by Smithsonian Institution, 1407, 1419, 1505.

Meteorology.
  Establishment of system of meteorology by Smithsonian Institution, 1407, 1409, 1425, 1426.

National Academy (*America*).
  The Academy was incorporated by Congress, but is not supported by it; it has no lodgment; meets at Washington now, 1525–1529.

Natural History.
  Promotion of natural history knowledge by Smithsonian Institution, 1407, 1421, 1422, 1426, 1489, 1490.
  Large amount of natural history knowledge obtained by American coast surveys, 1461–1464.

Observatory.
  United States' Government appropriate an annual sum for maintenance of a national observatory, which is placed under Navy Department, 1443.
  The establishment of an observatory would come within the purpose of the Smithsonian Institution, 1517.

Original Research.
  Promotion of original research by Smithsonian Institution and by Professor Bache, 1407, 1418-1422, 1424, 1502–1505, 1545-1549.
  The American States vote sums for original scientific research of a practical character, as geological surveys, &c., 1438 1443, 1448, 1461–1465.
  Those employed in original research should also be teachers; the teaching should be secondary, 1522-1524, 1545–1553.

Philadelphia Academy.
  The Academy is not supported by the State of Pennsylvania, 1530.

Philology.
  Promotion of philological knowledge by Smithsonian Institution, 1407, 1488.

Physics.
  Promotion of the science of physics by Smithsonian Institution; physical laboratory and instruments in the institution before the fire, 1407, 1468, 1503, 1504, 1517, 1518, 1520.
  Good physical cabinets in several of the States' science schools, 1519.

Professors.
  At the Smithsonian Institution it was originally intended to have professors, 1466.
  American Government should support professors similar to those in the colleges of France; their tenure of office to depend upon results; they should teach as well as investigate, but teaching should be secondary, 1506–1509, 1520–1524, 1545–1553.
  The German system of professors might be advantageous, under restriction, 1554.

Railways (*American*).
  Large amount of money expended by American Government on surveys and publications relating to railways, 1542-1544.

Royal Institution.
  Instanced as a model institution, doing honour to England, 1551.

Scholarships.
  No national scholarships in America, 1435, 1436.

Schools.
  System of graded schools in certain States of America; large number of normal schools for teachers, 1456, 1541.
    See *Elementary Schools.*

Science.
  Promotion of science by Smithsonian Institution, 1403–1427, 1466–1469, 1475–1524, 1528, 1545–1553, 1566–1573.
  Geological and coast surveys undertaken by United States Governments, publication of voyages, &c., 1438–1442, 1461–1465, 1470, 1542–1544, 1568.
  Applied, not theoretical, science is in demand in America; abstract science requires support, 1448, 1509.
  Capacity for original science should be consecrated to research, 1520, 1552.
  In American schools, scientific instruction is probably given, although not necessarily required, 1541, 1564.
  Allusion to smallness of amount for scientific purposes placed at disposal of Government Grant Committee of Royal Society, 1573, 1574.

Science Examinations.
  In America, there are no national science examinations like those of the Science and Art Department, 1437.

Scientific Institutions.
  Might combine experimental research with practical teaching, but the former is of the greater importance, 1545–1553.
    See *Smithsonian Institution.*

Scientific Publications.
  Publications of the Smithsonian Institution, their distribution by international exchange, &c., 1407, 1419, 1422, 1424, 1426, 1475–1479, 1487–1501, 1511–1516, 1568.
  Publication of voyages, transactions, &c. by American Government, 1470 1474, 1542–1544, 1526, 1535, 1542–1544.
  Great sale of elementary science books in America, 1541, 1564.

Scientific Societies.
  International exchanges of books, &c. between scientific societies effected by Smithsonian Institution, 1407, 1426, 1427.
  In America, scientific societies do not receive Government aid, except in special cases; such aid should be given, 1470 1474.

Smithsonian Institution (*Washington*).
  Its foundation; aid to geology, meteorology, philology, &c.; library, museum, plants, gallery of art; support from Congress; publications; international exchange of publications and specimens; income; government; staff, &c., 1403, 1407–1427, 1466-1469, 1475–1488, 1511–1518, 1566–1570.
  The institution works at present in the direction of natural science, 1489, 1490.
  No professors in the institution like those in the colleges of France; desirable there should be, 1506–1510.
  The institution might be made a centre of teaching as well as of research, 1545–1549.
  The institution could dispense more than it does, but a saving for contingencies is made, 1571, 1572.
  Board of regents of Smithsonian Institution contrasted with Government Grant Committee of Royal Society, 1573.

Teachers.
  In America, there is a large number of normal schools for teachers, 1541.

Text-books.
  Great sale of elementary science books in America, 1541, 1564.

United States. See *America.*

Universities of America. See *America*

Henry, Prof.—cont.

Virginia University.
- Is supported by the State, 1447.

Washington.
- Agricultural Department established at Washington by Government, 1422, 1535.
  - See *Smithsonian Institution.*

Yale College (New Haven).
- Many American engineers, surveyors, &c. have been educated at Yale College; it was endowed by an individual; it is well supplied with apparatus, 1519, 1558, 1560.

STRANGE, Lieut.-Col. ALEXANDER, F.R.S. (Index of his Evidence.)

Academies of Science.
- Objection to paid academies; continental academies may result from absence of private societies, 11,035–11,038.

Accommodation for Science Purposes.
- Accommodation for scientific societies at Burlington House; a general meeting-room, library, &c. would economize space; difficult to decide what societies are entitled to Government lodging, 10,443–10,476.

America.
- Important investigations of properties of iron in America, 10,971.

Apparatus for Science Purposes.
- Important apparatus possessed by Standards' Department; construction of thermometers, &c., 10,381–10,416.
- Accuracy of thermometers of great importance to physiologists, 10,433.
- Importance of having a museum of scientific apparatus, 10,434–10,442.

Artillery. See *Metallurgy.*

Astronomy.
- Greenwich Observatory is an efficient institution, but more extensive astronomical observations are required, 10,315–10,328.
- Study of the sun should be systematic; observatories should be erected in England and the colonies; continuity of observations essential, 10,316–10,328.
- Kew photographic sun observations have ceased; spectroscopic observations are being carried on by Dr. Huggins and others, 10,318–10,320.
- Physical astronomy only should be undertaken by Greenwich Observatory, 10,341, 10,441.

Boards of Visitors.
- Objection to boards of visitors like those of Greenwich Observatory, 10,349.

British Association.
- British Association made grants towards taking photographic sun observations at Kew, 10,318.
- Letter to British Association on State laboratories, 10,362.

Burlington House. See *Scientific Societies.*

Chemistry.
- Importance of chemistry in Government institutions; chemical and physical laboratories should be separate, administratively, 10,356, 10,413, 10,417–10,423, 10,441.

Conservatoire des Arts et Métiers (Paris).
- This country should have a museum like the Conservatoire des Arts et Métiers, 10,431–10,442.

Continent.
- Meteorology greatly attended to on the continent, 10,339.
- Absence of private scientific societies on the continent, 11,037.

Council of Scientific Advice.
- Importance of appointing a consultative council for science; sketch of such a council; objection to a paid academy, 10,984–11,038, 11,047, 11,048.

Education.
- Elementary instruction should not be given by men distinguished for investigation, 10,361.

Engineering.
- Modern engineering, in England, tends to obstruct scientific ideas, 10,971–10,975.

France.
- Great attention paid to meteorology in France, 10,339.
- Objection to paid academies for England, like those of France, 11,035–11,038.

Germany.
- Meteorology greatly promoted in Germany, 10,339

Strange, Lieut.-Col.—cont.

Government.
- State aid should be systematically given to science, 10,314–10,476, 11,039–11,051.
- Enumeration of Government scientific institutions, 10,315.
- Government should promote meteorological science by acting in concert with colonies and foreign nations, sending out ships, &c., 10,329–10,349.
- For promotion of science, there should be, under Government, observatories for astronomical and terrestrial physics; laboratories, physical, metallurgical, chemical, and physiological; extension of Standards' Office and of natural history collections, 10,441.
- Provision by Government for scientific societies; difficulty in deciding what societies are entitled to lodging, 10,443–10,476.

Grants for Science Purposes.
- Grants for sun observations made by British Association and Royal Society, 10,318.
- 10,000*l.* granted annually by Government for meteorological observations, 10,329.
- Government grants should be made to any institution or person promoting science, 10,369–10,372.
- Principle of present Government grant is excellent, but it should be 10,000*l.* instead of 1,000*l.*, 10,372, 11,039–11,051.
- Grants of money for science will not supersede necessity for establishing new Government institutions, 11,051.

Greenwich Observatory.
- Greenwich Observatory should be relieved of magnetism and meteorology, and relegate its researches to physical astronomy, 10,341.
- Boards of visitors, like those of Greenwich, are undesirable, 10,349.
  - See *Observatories.*

Italy.
- Great attention paid to meteorology in Italy, 10,339.

Kew.
- Kew a good position for an observatory, 10,323.
  - See *Observatories.*

Laboratories.
- Necessity for a State physical laboratory; scientific, not educational; administered separately from chemistry, 10,350–10,380, 10,441.
- Desirability of having a State chemical laboratory, 10,356, 10,413–10,423, 10,441.
- Importance of a metallurgical laboratory; it might form a portion of a State physical laboratory, 10,411–10,415, 10,441, 10,963–10,975.
- Fine private laboratory of Lord Lindsay, 10,420.
- State physiological laboratories desirable, 10,434, 10,441.

Lectures.
- Officers of State scientific institutions should give lectures, 10,425, 10,426, 10,441.

Lindsay, Lord.
- Superior private laboratory of Lord Lindsay, 10,420.

London.
- State laboratories should be founded at first as near London as possible, 10,367.

Metallurgy.
- A metallurgical laboratory might form a portion of a Government physical laboratory, 10,411–10,415, 10,441, 10,963–10,975.
- Illustrations showing necessity for a national metallurgical laboratory, 10,963–10,975.
- Enormous national importance of investigating the properties of different kinds of iron, for artillery, &c., 10,963–10,971.

Meteorology.
- Meteorological Office is doing well, but not all that is required; it should act in concert with colonies and foreign nations, 10,329–10,349.
- Local meteorology is useless; it should be studied all over the surface of the globe, 10,338.
- On the continent, great attention is paid to meteorology, 10,339.

Minister of Science.
- Appointment of a Minister of Science essential; preferably he should be for science only; he should have a permanent under-secretary, &c., 10,980–10,984.

Museums.
- Importance of having a State museum of machines, scientific instruments, &c., like the Conservatoire des Arts et Métiers, 10,431–10,442.

Strange, Lieut.-Col.—cont.

Natural History.

Every means should be taken by Government to advance natural history science, by attaching naturalists to ships of the Royal Navy, extension of collections, &c., 10,424–10,432, 10,441.

Observatories.

Greenwich Observatory fulfils its purpose, but is not adapted for the extended observations now required, 10,315–10,328.

Observatories for study of the sun should be erected in England and the colonies, 10,316–10,328.

Kew Observatory; photographic sun observations not now made; Mr. Gassiott's grant to Kew; study of the sun not provided for, 10,318–10,324.

Seven observatories under control of Meteorological Office, 10,329–10,349.

State observatories essential for physical astronomy and terrestrial physics, 10,441.

Original Research.

Men capable of research should not teach elements, 10,361.

State laboratories should be open for pursuit of research to others besides their officers, 10,363–10,368.

Pensions.

Pensions desirable for members of a scientific council, 11,002, 11,003.

Photography.

Photographic sun observations, irregularly made at Kew, have ceased; continuity of such observations is essential, 10,318–10,321.

Physics.

Necessity for a State physical laboratory, for scientific, not educational, purposes, 10,350–10,380, 10,441.

Physiology.

Importance to physiologists of accurate thermometers, 10,433.

Desirability of having State physiological laboratories, 10,434, 10,441.

Royal Society.

Grant given by Royal Society for spectroscopic sun observations, 10,318.

Funds for Meteorological Office are managed by a committee of the Royal Society, 10,329–10,349.

Royal Society stands upon a different footing to other scientific societies, 10,469–10,474.

10,000*l.* (instead of 1,000*l.*) should be allowed to Royal Society for science purposes, 11,040–11,051.

Russia.

Meteorological science is greatly promoted in Russia, 10,339.

Science.

National advantage of cultivation of all branches of science; Government should aid this, 10,313, 10,314, 11,039–11,051.

Government scientific institutions; their insufficiency and want of system; enumeration of institutions which should be supported by the State, 10,315–10,442.

Meteorology in England has no scientific basis whatever, 10,333.

Importance of State metallurgical investigations, 10,963–10,975.

Unsatisfactory position of science in England; it should be brought fully before the nation, through Parliament, 10,976–10,980.

Importance of appointing a Minister of Science and a consultative council, 10,980–11,038, 11,047, 11,048.

Scientific Societies.

Importance of existing scientific societies; aid given them by Government; accommodation at Burlington House; under one roof, several societies might use one theatre, library, &c., 10,443–10,476, 11,037.

Absence of private scientific societies on the continent, 11,037.

Standards' Office.

Standards' Office; its recent development; valuable apparatus possessed by it; it maintains in its integrity the units of length, weight, and capacity; extension requisite, 10,381–10,416, 10,441.

AIRY, GEORGE B., Esq., C.B., F.R.S. (Index of his Evidence.)

Academies of Science.

Objection to a paid academy of sciences for England; they have been useful in Russia and France, 10,521, 10,540.

Airy, G. B., Esq.—cont.

Admiralty.

Approval of Greenwich Observatory being under the Admiralty, 10,524–10,528.

Apparatus for Science Purposes.

Want of mathematical knowledge of makers of scientific apparatus, 10,494, 10,495.

Museums of scientific instruments might be advantageous, 10,495.

Liberality of Admiralty in regard to Greenwich Observatory apparatus, 10,527, 10,528.

Universities should have accessible apparatus for prosecuting scientific research, 10,532–10,537.

Astronomy.

Public observatory for researches in physics of astronomy desirable; Astronomer Royal might control it; only Government could institute it, 10,480–10,492.

In proportion to other sciences, Government has done too much in favour of astronomy, 10,519, 10,520.

Astronomy and navigation are the objects for which Greenwich Observatory was established, 10,524.

Cambridge University.

Cambridge University the best source for scientific education; too much confined to pure mathematics; change of examiners desirable, 10,496–10,510, 10,538, 10,539.

Professorial and tutorial teaching at Cambridge should be connected, 10,501, 10,502.

Chemistry.

Government has hitherto done too little (in proportion to other sciences) for chemistry, 10,519, 10,520.

Continent.

More done for science on the continent than in England, 10,560–10,565.

Council of Scientific Advice.

Objection to a permanent paid council of scientific advice; Government should call upon special persons, 10,492–10,494, 10,513, 10,514, 10,522.

Examinations.

Examinations at Cambridge; want of science in examiners; examiners foreign to Cambridge desirable; changes are impending, 10,496–10,510, 10,538, 10,539.

France.

Paid academies of science have been found serviceable in France, 10,521.

Government.

An observatory for researches in physics of astronomy could only be instituted by Government, 10,480–10,488.

Aid of Government funds should be given for special scientific investigations, 10,492–10,494.

Government could not undertake to promote investigations in natural philosophy, 10,511, 10,512.

Government aid might be given to science where private exertion has been made; many new Government institutions are not requisite, 10,513–10,518.

Approval of the Government Grant Committee, 10,515.

Government has hitherto done too much, in proportion, for astronomy, and too little for chemistry, &c., 10,519, 10,520.

Better for Government to get advice when necessary, than to have a paid consultative council, 10,522.

Scientific societies and Government need not be more closely connected than at present, 10,541.

Approval of Royal Society as scientific adviser of Government, 10,543–10,559.

Grants for Science Purposes.

Government grants for science best given to those who require assistance, to be employed at their convenience, 10,480–10,520.

On the continent, university funds are provided by the State, 10,563, 10,564.

Greenwich Observatory.

Greenwich Observatory might have a department for physics of astronomy; room might be made by degrees, 10,477–10,488.

Objection to great amount of printing done for Greenwich Observatory, 10,488, 10,499.

Meteorological and magnetic observations are carried on at Greenwich; approval of this, 10,490–10,492.

Approval of Greenwich Observatory being under the Admiralty, 10,524–10,528.

Greenwich Observatory was established for astronomy and navigation; the latter is its main object, 10,524–10,528.

Magnetism. See under *Meteorology.*

AIRY, G. B., Esq.—cont.

Mathematics.
- Want of mathematical knowledge of scientific apparatus makers, &c., 10,494, 10,495.
- Pure mathematics too much studied at Cambridge, 10,496–10,498.
- Mathematical tripos examinations at Cambridge should be conducted partly by examiners not belonging to University, 10,505.

Meteorology.
- Meteorological and magnetic observations should be carried on, as at present, at Greenwich, 10,490, 10,491.

Minister of Education.
- Minister of Education not necessary for control of Greenwich Observatory, 10,524.

Museums.
- Museums of scientific instruments might be advantageous, but mathematical education is what is really wanted, 10,494, 10,495.

Natural Philosophy.
- Government could not undertake promotion of investigations in natural philosophy, 10,511, 10,512.

Navigation.
- Navigation is the main object for which Greenwich Observatory was established, 10,524–10,528.

Observatories.
- A public observatory for researches in the physics of astronomy desirable; meteorological and magnetic observations should be continued to be carried on at Greenwich, 10,480, 10,490, 10,491
  - See *Greenwich Observatory.*

Original Research.
- Government could take no action in regard to promotion of research, 10,511, 10,512.
- The larger the establishment, the likelier its head to pursue research, 10,529–10,531.
- Universities should afford facilities for prosecution of original research, 10,532–10,537.

Physics.
- One public laboratory at least, for researches in physics of astronomy, desirable, 10,480–10,488.

Printing of Scientific Papers.
- Objection to the great amount of printing done for Greenwich Observatory, 10,488, 10,489.

Professors.
- Teaching of Cambridge professors should be connected with tutorial instruction, 10,501, 10,502.

Royal Observatory (Greenwich). See *Greenwich Observatory.*

Royal Society.
- Royal Society, with its special committees, the best scientific adviser of Government, 10,543–10,559.

Russia.
- Paid academies of science have been found necessary in Russia, 10,521.

Science.
- Promotion of science at Greenwich Observatory, &c., 10,477–10,566.
- More done for science abroad than in England, 10,560–10,565.
- Promotion of science at Cambridge University, 10,496–10,510.

Scientific Societies.
- Closer connexion between Government and scientific societies not desirable, 10,511.

Spectroscopy
- Spectroscopy has been studied more actively on the continent than in England, 10,561, 10,563

Standards' Department.
- Standards' Office is really directed by the Warden (not by a Commission); approval of this; it should be confined to its own subjects, 10,489, 10,492.

Universities.
- Universities should offer all facilities for prosecuting original research, 10,532–10,537.
- On the continent, University funds are provided by Government, 10,561

JOULE, JAMES PRESCOTT, Esq. D.C.L., F.R.S. (Index of his Evidence.)

Apparatus for Science Purposes.
- Advantage of having scientific apparatus exhibited in museums; patented apparatus being specially distinguished, 10,578, 10,586–10,589, 10,668–10,670
- Desirability of State aid being given towards scientific apparatus for research, 10,607–10,633.
- Importance of correct scientific instruments; Government might aid in this direction, 10,634–10,638.

JOULE, J. P., Esq.—cont.

Astronomy.
- More observatories are wanted for watching astronomical phases, 10,572.
- Expeditions for observing eclipses, transits, &c. should be sent out more frequently, 10,639–10,645.

Catalogues.
- State aid should be given towards publication of scientific catalogues; Royal Society's Catalogue should be published wholly at Government expense, 10,603–10,606.

Council of Scientific Advice.
- A board of science might be created, to receive suggestions from scientific societies, and to advise Government, 10,661–10,665.

Government.
- Science should be more promoted by Government; aid should be given to observatories, museums, libraries, catalogues, laboratories, expeditions, &c., 10,567–10,673.
- In scientific matters Government might have a board of science to advise them, 10,661–10,665.
- Government assistance to science would tend to encourage local effort, 10,667.

Grants for Science Purposes.
- Government grants should be made towards observatories, museums, libraries, laboratories, societies, &c., 10,567–10,673.

Laboratories.
- Public laboratories, with apparatus, are needed; they might be connected with local institutions, 10,612–10,632.

Libraries.
- Funds for establishing libraries should be furnished by Government, 10,596–10,602.
- Libraries round Manchester wanted, 10,602.

Manchester.
- Erection of an observatory near Manchester desirable, 10,572.
- Government aid desirable to render more complete the museums of Manchester; patented inventions wanted, 10,581–10,590.
- Manchester Philosophical Society; its important library; want of funds, &c., 10,596–10,602, 10,609, 10,620, 10,671–10,673.
- Towns surrounding Manchester should have libraries, 10,602.

Museums.
- Importance of museums; they should be numerous and accessible; Government should aid local effort in their establishment and promotion, 10,578.
- In a museum of machines, processes, &c., those patented should be specially distinguished, 10,668–10,670.

Observatories.
- More State observatories desirable, for study of the sun, winds, tides, &c., 10,568–10,577.

Original Research.
- State aid wanted for original research; laboratories, apparatus, &c. should be provided; personal expenses of inquirers should be allowed, 10,607–10,633.

Patents.
- Importance of patented inventions being exhibited in museums, and specially distinguished from those not patented, 10,590, 10,668–10,670.

Registration of Mortality.
- More complete registration of disease and mortality wanted; it should be carried out by Government, 10,646–10,653.

Royal Society.
- Government should bear the whole expense of publication of the Royal Society's Catalogue of Scientific Papers, 10,603.
- Royal Society should be able to recommend scientific expeditions to Government, 10,641.

Science.
- Government should give greater aid to science in regard to adulterations, sewage, registration of disease, &c., 10,567–10,673.
- Local effort for science would be stimulated by Government aid, 10,667.

Scientific Societies.
- Philosophical Society of Manchester; importance of its library; want of funds, &c., 10,596–10,602, 10,609, 10,620, 10,671–10,673.
- Government aid to scientific societies desirable, 10,671–10,673.

Joule, J. P., Esq.—cont.

South Kensington.
PatentMuseum, South Kensington; it would be sufficient, if complete, 10,595.

Survey Expeditions.
Scientific expeditions should be more frequent, and on a larger scale, 10,639–10,645.

THOMSON, Sir WILLIAM, F.R.S. (Index of his Evidence.)

Apparatus for Science Purposes.
Apparatus for a State physical laboratory would be expensive; funds should not be limited to a fixed endowment, 10,702–10,714.

Astronomy.
Importance of promoting research in astronomical physics; observatory wanted, 10,681, 10,697.
In proposed council of scientific advice, astronomical physics should be separately represented, 10,690.
See *Tides.*

Cambridge University.
Severity of examinations in Cambridge Senate House should be reduced, &c., 10,742, 10,767–10,770.
See *Universities.*

Chemistry.
There should be a secured position for chemists, &c. who devote themselves to research, 10,683, 10,736.
Government (by advice of a scientific council) should promote efficiency of chemical laboratories, 10,683–10,689, 10,696–10,714.

Council of Scientific Advice.
Desirability of having a council to assist Government in scientific matters; mistakes through want of this, 10,674–10,777.
Approval of having a single body for advising Government, not small committees, 10,677, 10,678.
A scientific council should represent the different branches and applications of science; members should have good remuneration, and be appointed for life, 10,690–10,695, 10,725–10,735, 10,750–10,757, 10,765–10,766.
Existing governmental scientific departments might consult with proposed council of advice, 10,750, 10,751.

Engineering.
Importance of physical laboratories for students of engineering, 10,683.

Examinations.
Competitive examinations an obstruction to progress of science, 10,741, 10,742, 10,758.
Examinations should not be separated from the teaching; the teacher should be the examiner, 10,741.
Aptitude for research, rather than examination results, should decide award of fellowships, 10,767–10,777.

Fellowships.
Fellowships should be awarded for skill in scientific investigations, 10,767–10,777.

France.
Vigorous promotion of science in France, 10,697.

Government.
Government should be assisted in scientific matters by a council of advice, 10,674–10,777.

Grants for Science Purposes.
Scientific council preferable to Royal Society for management of Government Grant Fund, 10,734, 10,735.

Greenwich Observatory. See *Observatories.*

Laboratories.
Government (by advice of a scientific council) should promote efficiency of local laboratories, 10,683–10,689, 10,698–10,714, 10,736–10,740.
Importance of physical laboratories in regard to telegraphy, engineering, &c., 10,683.
National scientific laboratories should be freely open to amateurs, professors, students, &c., 10,743–10,746.

London.
Neighbourhood of London the best place for establishing institutions for research, 10,696, 10,711.

Minister of Science.
Necessity for a special Minister of Science, not under any education board, 10,747–10,749, 10,759–10,764.

Observatories.
Greenwich Observatory is an honour to the country, 10,681.
An observatory for astronomical physics is much wanted, 10,697.

Thomson, Sir W.—cont.

Original Research.
Government should devote care and money to promotion of scientific research, 10,681–10,689.
For original research, there should be national laboratories for physics, chemistry, and physiology, and an observatory for astronomical physics, 10,696–10,714.
Professors should be allowed time for original investigations, 10,739, 10,740.
National importance of men being able to live on scientific research; at present they cannot, 10,736–10,740.
Cambridge Senate House examinations might be reduced, with a view to research, 10,742, 10,767–10,770.

Physics.
Endowment of physical laboratories (under advice of a scientific council) desirable, 10,683–10,689, 10,696–10,714.

Professors.
Importance of professors being allowed time for original research, 10,739, 10,740.
Examinations should be conducted by the teacher, 10,741.

Royal Society.
A council of scientific advice would be a better body for administering the Government Grant Fund than the Royal Society, 10,734, 10,735.

Science.
Necessity for a State council of scientific advice; mistakes for want of this, viz., "Captain," stone and ventilation of Houses of Parliament, &c., 10,674–10,777.
Weights and measures should be under scientific surveillance, 10,678–10,680.
Government should support institutions for pure scientific research; besides Greenwich Observatory, there are wanted laboratories for physics, chemistry, and physiology, and an observatory for astronomical physics, 10,696–10,714.
Necessity for a special minister of science and scientific instruction, 10,747–10,749, 10,759–10,764.

Standards. See *Weights and Measures.*

Students.
Obstructions to students from competitive examinations, 10,741, 10,742, 10,758.
Students should be able to obtain fellowships on showing aptitude for scientific research, 10,767–10,777.

Telegraphy.
Importance of physical laboratories for students of telegraphy, 10,683.

Tides.
Government should undertake secular observations of the tides, 10,715–10,724.

Universities.
Evils of University competitive examinations, 10,741, 10,742, 10,758.
Universities might aid students in promotion of scientific research, 10,742.
University fellowships should be given for aptitude in research, rather than in examination results, 10,767–10,777.

Weights and Measures.
Want of better arrangements for the national standards of weights and measures, 10,678–10,680.

GORE, GEORGE, Esq., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
For original investigation, laboratories should be purposely constructed, 10,892.

Aix-la-Chapelle.
Great science school newly erected at Aix-la-Chapelle cost 70,000*l.*, 10,825–10,836, 10,845.

Berlin.
Important chemical laboratory at Berlin, 10,830–10,832.

Birmingham
No provision in Birmingham for promotion of scientific research; effort formerly made, 10,885, 10,908–10,919.

Bonn.
Great chemical laboratory at Bonn; instruction, not research, the primary object, 10,836, 10,841, 10,842.

Carlsruhe.
There is a large polytechnic school at Carlsruhe, 10,385.

Chemistry.
Chemical laboratories for purely scientific investigations should be established by Government, 10,782–10,812.
Important chemical laboratories of Germany, 10,822–10,845

GORE, G., Esq.—*cont.*

Council of Scientific Advice.
Desirability of having a permanent Government department for science, composed of salaried officers, 10,813–10,818, 10,895–10,897.

Germany.
More scientific investigations and important laboratories in Germany than in England, 10,822–10,845, 10,876.
Promotion of science by the Prussian Government, 10,846.

Grants for Science Purposes.
Government grants might be given to leading scientific institutions for purposes of abstract original research, 10,819, 10,878–10,881.
If State laboratories be not founded, extension of pecuniary aid to investigators desirable, 10,889–10,893.
Government Grant of Royal Society good in principle, but insufficient, 10,898–10,907.
Grants to investigators should include payment for time and labour, 10,902–10,906.

Laboratories.
Government should establish laboratories, conducted by paid officers, employed permanently in research only, 10,782–10,812, 10,897.
National laboratories should be solely devoted to abstract science, inquirers selecting their own line of research, 10,810, 11,811, 10,851–10,874.
Important laboratories in Germany, 10,822–10,845.
If State laboratories be not founded, extended pecuniary aid to investigators desirable, 10,889–10,893.

Lectures.
Men carrying on research in national laboratories should not lecture, 10,804–10,809.

Leipzig.
The largest laboratory on the continent is at Leipzig, 10,831–10,835.

Minister for Science.
Minister for Science desirable; he need not be a scientific man, 10,813–10,818.

Original Research.
For abstract scientific research Government should establish laboratories, with permanent investigators, 10,782–10,812, 10,851–10,863, 10,897.
Scientific investigators in national laboratories should not lecture, 10,804–10,809, 10,863.
State grants might be given to principal scientific institutions to carry on research, 10,819.
Less original research in this country than on the continent, 10,821–10,825, 10,837, 10,838.
Every teacher of a higher kind ought to engage in original investigation, 10,860–10,863.
Scientific investigators should receive State aid, if State laboratories be not instituted, 10,889–10,893.
Grants to investigators should include payment for time and labour, 10,902–10,906.

Physics.
Laboratories for investigations in physics should be established by the State, 10,782–10,812.

Pomerania.
State laboratory at Griefswald, in Pomerania, 10,835.

Professors.
State grants for original research might be given to chief scientific institutions; professors to carry out such research, 10,819, 10,878–10,881.
High-class scientific teachers should be also investigators, 10,860–10,863.

Prussia. See *Germany.*

Royal Society.
Royal Society the best scientific body to advise Government at present, 10,894.
Approval of Government Grant system of Royal Society, but amount is insufficient, 10,898–10,907.

Schools.
Important polytechnic schools at Aix-la-Chapelle, Carlsruhe, &c., 10,821–10,845.
All our schools should have scientific head masters, 10,848.

Science.
Government should promote science by establishment of laboratories under paid officers, 10,782–10,812, 10,851–10,893.
A permanent Government department for science desirable, 10,813–10,818, 10,851–10,860.
Leading scientific institutions should receive State aid for conducting research, 10,819, 10,878–10,881.

GORE, G., Esq.—*Science—cont.*
Promotion of science on the continent greater than in England, 10,821–10,846.
Science must be more encouraged by the Government and Universities, 10,847–10,850.
Schools should have scientific head masters, 10,848.
Investigation makes a more accurate teacher of science, 10,860.
See *Grants for Science Purposes.*

Stuttgart.
Large polytechnic school at Stuttgart, 10,835.

Teachers. See *Professors.*

Universities.
Science must be more encouraged in universities; colleges should have a scientific department, 10,847–10,850.

CARPENTER, WILLIAM B., Esq., M.D., F.R.S. (Index of his Evidence.)

Biology.
No encouragement for biological science; Government or Universities should provide for higher researches and teaching, 10,920–10,929.
State aid to deep-sea researches, 10,930–10,935.
Sea captains, &c. should be induced to collect natural history specimens; many museums are thus enriched, 10,936–10,939.
Government should institute biological laboratories, 10,942–10,951.

British Museum.
British Museum, if removed, might have a biological laboratory connected with it, 10,945.

Brown Institution.
Brown Institution founded for study of diseases of animals; used for research, 10,948–10,950.

Cambridge University.
More should be done for science by Cambridge University, 10,929, 10,954.

Chemistry.
Chemical science is in a better position than biological, 10,921.

Deep-Sea Dredging. See *Original Research.*

Fellowships.
University fellowships should be devoted to men engaged in scientific research, 10,929, 10,954–10,956.

France.
Science is considered a profession in France, 10,923.

Germany.
Professional occupation for students of biology in Germany, 10,921–10,924.

Government.
Government should promote biological teaching and research, 10,920–10,961.
Council of Royal Society the best scientific adviser of Government, 10,930–10,941.
Government aid to circumnavigation expedition, &c., 10,930–10,935.

Grants for Science Purposes.
Liberal provision by Government for deep-sea researches and circumnavigation expedition, 10,933–10,935.

Laboratories.
Desirability of having Government biological laboratories, each under a permanent officer, 10,922, 10,942–10,951.
State physiological laboratory needed; no body has funds for this; it might be attached to proposed School of Science, 10,922, 10,942, 10,944, 10,946.
For marine natural history a laboratory on the coast would be essential, 10,946.

London University.
University of London might be empowered to take up higher and special scientific teaching, 10,926, 10,952, 10,953.

Metropolitan College of Science (proposed).
Proposed College of Science might have a physiological laboratory attached, 10,946.

Museums.
Valuable natural history specimens supplied to museums by sea captains, &c., 10,936–10,938.
Museums should not rely upon trade collectors, 10,960.

Natural History Specimens.
Naval officers, &c. should be induced to collect natural history specimens, and results should be published, 10,936–10,939, 10,961.
Trade collectors' specimens should not be relied on for museums, 10,960.

CARPENTER, Dr.—cont.

Naval College.
- Professor of the Naval College should interest students in biology, and publish results brought to him, 10,938, 10,957–10,959, 10,961.

Original Research.
- Provision should be made by Government or Universities for carrying on physiological research, 10,922, 10,929, 10,942–10,951.
- University fellowships should be given to men employed in original research, 10,929.
- Provision made by Government for carrying on the deep-sea researches, 10,930–10,935.
- Royal Navy officers, &c. should collect specimens with a view to research, 10,936–10,939.

Oxford University.
- Oxford University should do a great deal more to promote science, 10,929.

Physiology. See *Biology*.

Professorships.
- Numerous professorships of biological science in Germany, 10,922.

Royal Navy.
- Officers of Royal Navy should be induced to collect biological specimens; results should be published, 10,936–10,939, 10,961.

Royal School of Mines.
- Royal School of Mines the only institution at which higher teaching is given; its development would be most important, 10,925, 10,929.

Royal Society.
- Royal Society the best scientific adviser of Government; permanent connexion with Government desirable, 10,931, 10,940, 10,941.

Science.
- Promotion of biological science; State aid required, 10,920–10,961.
- Science more a profession in Germany and France than in England, 10,921–10,924.
- Greater aid to science should be given by universities, 10,922–10,929, 10,954–10,956.
  - See *Original Research.*

Scientific Publications.
- Government should publish results obtained from expedition collections, &c., 10,939, 10,957–10,959.

Students.
- Good opportunities for students of biology in Germany, 10,922.

Survey Expeditions.
- Government provision for deep-sea dredgings and the circumnavigation expedition, 10,930–10,935.

Universities.
- Universities should give greater aid to science, 10,922–10,929, 10,954–10,956.
- Universities should make provision for promotion of physiological research, 10,922–10,929.
- Fellowships should be given by universities for maintenance of scientific investigators, 10,929, 10,954–10,956.
  - See *Cambridge University*, &c.

FRANKLAND, EDWARD, Esq., Ph.D., D.C.L., F.R.S. (Index of his Evidence).

Astronomy.
- Government laboratory for astronomical physics desirable, 11,064–11,073.

Biology.
- Biological laboratory should be provided by Government, 11,064–11,073.

Chemistry.
- More chemical research in France and Germany than in England, 11,053–11,061.
- Desirability of having a national chemical laboratory; metallurgy might be combined with it, 11,064–11,073.

Council of Scientific Advice.
- Approval of a scientific council, not too numerous, all important branches being represented; it might advise Government and the Bench, 11,079–11,088.

Courts of Justice.
- System of giving scientific evidence in courts of justice is most objectionable, 11,074–11,081.

Degrees.
- Original research should be required for highest degrees for science, 11,064.

FRANKLAND, E., Esq.—cont.

France.
- Rapid progress of chemical research in France, 11,053.
- Scientific research little pursued in France by private investigators, 11,064, 11,105.

Germany.
- Activity of chemical investigation in Germany, 11,053–11,061.
- Pursuit of original research is mostly confined to teachers in Germany, 11,064, 11,105.
- In Germany, experts employed in courts of justice, &c., are always placed on neutral ground, 11,074, 11,077.
- Laboratories for original research in Germany are connected with teaching institutions, 11,092, 11,093, 11,097–11,103.

Laboratories.
- National laboratories wanted for chemistry, physics, astronomical physics, and biology; private inquirers should be admitted; not to combine teaching, 11,064–11,073, 11,089–11,091, 11,095.
- Approval of connexion between laboratories and teaching institutions, 11,092–11,107.

London.
- State laboratories should be founded first in London, 11,071.

Medicine.
- Some new German chemical laboratories have a department for inquiries concerning medical jurisprudence, 11,103.

Metallurgy.
- Metallurgy might be combined with a national chemical laboratory, 11,072, 11,073.

Original Research.
- Original chemical research is languid in England, compared to France and Germany, 11,053–11,062.
- No real advancement in science without original research, 11,062, 11,063.
- For highest degrees in science, original research should be required, 11,064.
- Government should institute laboratories for original research, 11,064–11,073, 11,089–11,107.
- Private workers in original research are peculiar to England, 11,064, 11,105.
- Importance of research in connexion with teaching, 11,092–11,107.

Parliamentary Committees.
- Scientific evidence, as now given in parliamentary committees, is most objectionable, 11,074–11,081.

Physics.
- State laboratory for physics essential, 11,064–11,073.

Professors.
- Professors should conduct research, and devise researches for their students, 11,093.

Science.
- Progress of chemical science; more research on the continent, 10,053–11,107.
- State scientific laboratories essential for promotion of science, 11,064–11,073, 11,089–11,107.
- Great objection to present system of scientific evidence in parliamentary committees, courts of justice, &c., 11,074–11,081.
- Consultative council for science desirable, 11,079–11,088.
  - See *Original Research.*

Scientific Societies.
- English and German chemical societies contrasted; great number of papers communicated to the latter, 11,053–11,061.

Students.
- Students in laboratories should have researches devised for them by professors, 11,093.

SABINE, GENERAL SIR EDWARD, R.A., K.C.B., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
- Approval of accommodation for scientific societies at Burlington House; extended accommodation for more societies desirable, 11,119.

Board of Longitude.
- Royal Society preferable to Board of Longitude as scientific adviser of Government, 11,117–11,133.

British Association.
- Government receive favourably recommendations from British Association, 11,239.

SABINE, General Sir E.—cont.

British Museum.
- British Museum should be more useful for promotion of knowledge; it should grant loan of duplicate specimens to museums, 11,119, 11,264–11,271.

Burlington House. See *Accommodation for Science Purposes.*

Catalogues. See *Scientific Publications.*

Council of Scientific Advice.
- Desirability of Government having a consultative council; preference given to Royal Society over a re-constituted Board of Longitude, 11,117–11,133, 11,170.

Deep-sea Dredgings. See *Survey Expeditions.*

Examinations.
- Desirability of Government encouraging provincial scientific lectures, accompanied by examinations, 11,119.

Government.
- Report on methods by which Government could promote position of science, 11,117–11,136.
- Willingness of Government to entertain recommendations of Royal Society and British Association, 11,199–11,200, 11,239.
- Different branches of science being under different Government departments is not found inconvenient, 11,233.
- Scottish Meteorological Society has a fair claim on Government, 11,243–11,256.

Government Grant Committee. See *Grants for Science Purposes.*

Grants for Science Purposes.
- Royal Society Government Grant; it has been of great service; it should not be limited to 1,000*l.*; if increased, it would necessitate new arrangements, 11,109–11,169.
- Report of Government Grant Committee as to improving position of science by the State, 11,119.
- Frequent special grants have been made by Government on application of Royal Society, 11,139–11,145, 11,198, 11,199, 11,239.
- No Government grant exists for reward of discoveries, 11,179–11,182.

Lectures.
- Provincial scientific lectures, with examinations, should be established by Government, 11,119.

Libraries.
- Establishment of provincial libraries should be encouraged by the State, 11,119.

Magnetic Department.
- Magnetic Department admirably conducted; Royal Society consulted respecting surveys by Government, 11,200–11,211

Meteorological Department.
- Meteorological Department; its satisfactory state; expense 10,000*l.* a year; managed by eight members nominated by Royal Society, 11,212–11,263.
- Meteorological Office has two observatories in Scotland, 11,243.
- Scottish Meteorological Society supplies material to Registrar General; it has a fair claim on Government; more sanitary than meteorological, 11,243–11,256.

Museums
- Formation of provincial museums should be encouraged by the State; duplicates from British Museum, &c. should be distributed to them, 11,119, 11,264–11,271.
- Desirable, generally, that museums should be teaching institutions, 11,271, 11,272.

Natural History Specimens.
- Duplicates from British Museum, &c. should be distributed to provincial museums, 11,119, 11,264–11,271

Observatories See *Meteorology.*

Pensions.
- Civil Service Pension List should be augmented for science rewards, 11,119, 11,134, 11,179 11,182
- Government Grant Committee can award annuities; not desirable they should do so, 11,172, 11,173.

Royal Society.
- Administration of Government Grant by Royal Society, 11,109–11,169.
- Royal Society the best scientific adviser of the Government, 11,117–11,133, 11,170.
- Royal Society Catalogue of Scientific Papers; prepared by Society, and published at Government expense, 11,183–11,197.
- Royal Society's recommendations willingly attended to by Government, 11,135–11,145, 11,198, 11,199, 11,239.
  See *Grants for Science Purposes.*

SABINE, General Sir E.—cont.

Schools.
- Teaching of physical science in schools should be promoted by the State, 11,119, 11,120.

Science.
- Promotion of science by Royal Society, 11,109–11,272.
- Government rewards should be given to scientific discoverers, 11,119, 11,179–11,182.
- Report of Government Grant Committee as to improving position of science by the State, 11,119.
- No inconvenience from different branches of science being under different Government departments, 11,233.

Scientific Publications.
- National scientific publications should be more extensively circulated, 11,119.
- Government Grant Committee has contributed towards scientific publications in special cases, 11,172–11,178.
- Royal Society Catalogue of Scientific Papers; expenses of publication defrayed by Society and Government, 11,183–11,197.

Scientific Societies.
- Approval of Government providing accommodation for scientific societies, as at Burlington House, 11,119.

Scotland.
- Meteorological Office has two observatories in Scotland, at Glasgow and Aberdeen, 11,243.
- Scottish Meteorological Society has a fair claim on Government, 11,243–11,256.

Survey Expeditions.
- Recommendations of Royal Society respecting dredging expeditions; favourably received by Government; one expedition now preparing, 11,823–11,240.

FROUDE, WILLIAM, Esq., F.R.S. (Index of his Evidence.)

Admiralty.
- Admiralty committee on designs of ships; recommended investigations on oscillation of ships, &c., 11,289–11,297.
- Willingness of Admiralty to promote scientific investigations, 11,298, 11,300, 11,317, 11,334, 11,343.

Apparatus for Science Purposes.
- Physical apparatus costly; saving of expense by experimenters constructing their apparatus, 11,300, 11,301.

British Association.
- Scientific council preference to British Association as adviser of Government, 11,309.

Council of Scientific Advice.
- Approval of a scientific consultative council; preferable to advisers like Royal Society, &c., 11,281–11,298, 11,308–11,310.
- For a scientific council, a numerous body would not be necessary, 11,323–11,327, 11,337–11,340.

Engineers.
- Tendency of engineers to discountenance small scale trials, 11,342.

France.
- France ahead of England, in many respects, in naval architecture, 11,304–11,306.

Government.
- Science, both pure and in relation to commerce, should be promoted by Government, 11,276–11,298, 11,348.
- Government scientific council desirable, 11,281–11,298, 11,308–11,310, 11,323–11,327, 11,337–11,340.

Grants for Science Purposes.
- Grant of 2,000*l.* for investigations in naval architecture, 11,300, 11,316, 11,317.

Gunnery.
- Pecuniary importance to Government of scientific methods being pursued in questions of gunnery, 11,280, 11,303

Naval Architecture.
- In naval architecture, scientific methods are of pecuniary importance to Government, 11,280, 11,303.
- Mr. Childers' committee on construction of ships; less satisfactory than a scientific council, 11,287–11,298.
- Promotion by Admiralty of investigations relating to naval architecture, 11,298–11,352.
- Superiority of France in naval architecture, 11,304, 11,305.
- Scientific knowledge in relation to naval architecture has greatly increased; considerable improvements may be expected, 11,311–11,315, 11,333–11,336, 11,343, 11,344.
- Constructor of Navy's department is too much overworked to allow of investigation, 11,352.
  See *School of Naval Architecture.*

Froude, W., Esq.—cont.

Original Research.
Investigations relating to naval architecture are willingly aided by Admiralty, 11,298, 11,352.
Waste of money in Government departments, by conducting researches on too large a scale, 11,341–11,347.
New investigations cannot be carried on in Navy Constructor's department, on account of over-pressure of work, 11,352.

Practical Instruction.
Approval of theoretical and practical instruction being carried on *pari passu*, 11,328–11,332.

Royal Society.
A scientific council as adviser of Government preferable to Royal Society, 11,310.

School of Naval Architecture.
Good men have come from School of Naval Architecture, 11,315, 11,328.
Approval of education being, as at School of Naval Architecture, partly systematic, partly practical, 11,329–11,332.

Science.
Government should promote science, both with regard to pure science and to commerce, 11,276–11,281.
Consultative council for science desirable, 11,281–11,298, 11,308 11,310, 11,323–11,327, 11,337–11,340.
Scientific assistance in department of French Marine, 11,304, 11,305.
Scientific advancement should not depend on present haphazard method, 11,350.
See *Naval Architecture.* *Original Research.*

STEWART, BALFOUR, Esq., LL.D., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
State institution for physical experiments wanted; no existing building suitable, 11,354, 11,497–11,502.

America.
There is an observatory for solar research in America, 11,364, 11,476, 11,528.

Apparatus for Science Purposes.
Government might promote science by aiding colleges with apparatus, 11,354.
Meteorological instruments at Kew preferable to those at Greenwich, 11,455.

Astronomer Royal. See *Greenwich Observatory.*

Astronomy.
Want of system among workers in astronomy; provision for sun observations, &c. wanted, 11,354–11,369, 11,525, 11,526.
There are observatories for solar research in America, France, &c., 11,364, 11,476, 11,528.
Astronomer Royal should not be charged with meteorological observations, 11,456, 11,526.
See *Meteorology.*

Bombay.
There is a meteorological establishment at Bombay, 11,478.

Calcutta.
Calcutta has a meteorological office, 11,478.

Chemistry.
National importance of cultivation of chemistry, 11,354.

Colleges.
Government might furnish colleges with apparatus, and endow professorships, 11,354.

Council of Scientific Advice.
Paid council for science desirable; they should be observers, as well as advisers; 50 would be too many, 11,354, 11,377–11,387, 11,426–11,439, 11,486, 11,503–11,522.

France.
State observatory for solar research in France, 11,364, 11,479, 11,528.

Geology.
Geology is among the sciences which have received most support from the State, 11,354, 11,482.

Germany.
Position of science better in Germany than in England; brilliant discoveries of Germans, 11,388–11,394.
German professors receive State aid as well as fees; adoption of this plan desirable for England, 11,392–11,394.

Government.
Present position of science must be amended, not by private means, but by Government, 11,354–11,534.

Stewart, B., Esq.—*Government*—cont.
In Germany State aid is given to universities, &c., 11,392–11,394.
Support of scientific institutions by Government has not tended to lessen private research, 11,415–11,425.

Government Grant Committee.
Royal Society Government Grant Committee; its stoppage of funds for working the Kew photo-heliograph, 11,354–11,369.
See *Grants for Science Purposes.*

Grants for Science Purposes.
300*l.* or 400*l.* per annum wanted to continue working of Kew photo-heliograph, 11,354–11,369.
2,000*l.* extra wanted for publishing meteorological observations, 11,354, 11,372, 11,401, 11,402, 11,435–11,445.
State grants for science have not diminished private research, 11,415–11,425.

Greenwich.
Chief Astronomer should not be charged with meteorology, 11,403–11,414, 11,456, 11,526.
Greenwich Observatory, as a State institution, has not depressed private research, 11,416.
Preference of Kew to Greenwich for meteorological observations, 11,450–11,475.

India.
There are meteorological establishments at Bombay and Calcutta, 11,478, 11,527, 11,534.

Kew.
Sun observations formerly taken at Kew; suitability of Kew for this purpose; observations might be continued by Treasury grant, 11,354–11,369, 11,525, 11,526.
Kew is an observing place of the Meteorological Committee; Kew instruments preferable to those of Greenwich, 11,450–11,475.

Lockyer, Mr. J. N.
Mr. Lockyer's spectroscopic sun observations, 11,354, 11,524.

Magnetism. See under *Meteorology.*

Mauritius.
Meteorological Society and State Observatory in Mauritius, 11,478.

Minister of Science.
Desirable to have a Minister of Science, 11,354, 11,503–11,522.
See *Council of Scientific Advice.*

Metallurgy.
National importance of cultivation of metallurgy, 11,354.

Meteorology.
Letter on scientific organisation as regards meteorology, 11,354.
Meteorological Committee, its incompleteness, want of funds, &c., 11,354, 11,370–11,377.
Objection to present system of reducing meteorological observations; they should be reduced, printed, and published without exception; 2,000*l.* extra required for this, 11,354, 11,370–11,377, 11,395–11,402, 11,429–11,456.
Meteorological observations must be taken throughout the globe, 11,354, 11,476 11,481, 11,526–11,534.
India, America, France, &c. have meteorological observatories, 11,364, 11,476–11,480, 11,527–11,534.
Meteorological Office should be directed by one man, not the Astronomer Royal, 11,403 11,414, 11,456, 11,526.
Preference of Kew to Greenwich for carrying on meteorological observations, 11,450–11,475.
Meteorological and sun observations should go together, 11,527.

Observatories.
Observatories for meteorology, solar research, &c. in India, America, France, &c., 11,364, 11,476–11,480, 11,527–11,534.
See *Kew*, &c.

Original Research.
State grants for science have not impeded private research, 11,415–11,425.
Patents should not be taken for researches made in Government establishments, 11,487–11,496.

Patents.
Researches made in Government establishments should not be patented, 11,487–11,496.

Photography.
Photography in relation to astronomy; Kew photo-heliograph; should be aided by Government, as in Russia, 11,354–11,369, 11,479, 11,480, 11,528.

Physics.
Government institution wanted for physical experiments; thermometers, standards, &c. might there be tested, 11,354, 11,497–11,502.

STEWART, B., Esq.—cont.

Physiology.
State physiological laboratory a great desideratum, 11,354.

Printing of Scientific Papers. See *Scientific Publications.*

Professors.
Professors should receive State aid as well as fees, as in Germany, 11,392–11,394.

Professorships.
Government endowment of professorships desirable for furtherance of science, 11,354, 11,523.

Rome.
In Rome, Father Secchi undertakes astronomy, spectroscopy, &c., 11,529.

Royal Society.
Influence of Royal Society should be extended by being entrusted with larger grants, 11,424.
See *Government Grant Committee.*

Russia.
Sun-photographs are taken in Russia at Government expense, 11,354, 11,361, 11,479, 11,480, 11,528.

Science.
Present position of science, and its amendment, 11,354–11,534.

Scientific Publications.
Meteorological Committee should print and publish the actual figures of observation, 11,354, 11,370–11,377, 11,395–11,402, 11,429–11,445.

Scientific Societies.
Private associations cannot properly promote science 11,354.

Spectrum Analysis. See *Lockyer, Mr. J. N.*

Standards' Office.
A State physical institution would be an appropriate home for the national standards of weight, &c., 11,354, 11,502.

Statistics.
Statistics should be undertaken by Government, aided by a scientific council, 11,485, 11,486.

OWEN, RICHARD, Esq., M.D., F.R.S. (Index of his Evidence.)

Agriculture.
Agricultural experiments to be carried on under endowment of Mr. Bennet Lawes, 11,575.

Botany.
Evil of competing State institutions for botany; objection to transferring British Museum collection to Kew, 11,537, 11,538.
Survey expeditions might collect botanical specimens sufficient to furnish duplicates, 11,540.
Kew has space for all the needs of experimental botanical science, 11,574–11,577.
See *Agriculture.*

British Museum.
More spent on antiquities, &c. than on natural history at British Museum, 11,537.
Elementary lectures proposed to be given by keepers of natural history departments of British Museum, 11,537.
Survey collections should be sent to British Museum; it could then supply specimens to other museums, 11,537–11,541.
British Museum has a chemical laboratory, microscopes, &c., for pursuing research, 11,537, 11,563, 11,564.
Harm to natural history from competing institutions like British Museum and Kew, 11,537.
Increased grants will be essential when British Museum is transferred to South Kensington, 11,569.

Chemistry.
Chemical laboratory in connexion with British Museum, 11,537, 11,563, 11,564.

Council of Scientific Advice.
Difficulties in the way of a consultative council; one institution might be encouraged at the expense of others; minister and permanent secretary preferable, 11,357, 11,358, 11,545–11,562.

Grants for Science Purposes.
Increased grants for natural history will become essential, 11,569.
Considerable increase of Royal Society Government Grant desirable, 11,570–11,573.
100,000*l*. devoted to agricultural experiments by Mr. Bennett Lawes, 11,575.

OWEN, Prof.—cont.

Hunterian Museum.
State physiological laboratory should be connected with Hunterian Museum, 11,537, 11,566, 11,567.

Kew Gardens.
Evil to science of maintaining two such State institutions as British Museum and Kew, 11,537.
Bad influence of the herbaria work at Kew on the physiological work contemplated to be carried on there, 11,537.
Desirability of Kew as a locality for a State physiological establishment in reference to plants, 11,357.
Space exists at Kew Gardens for all needs of experimental botanical science, 11,574–11,577.

Laboratories.
British Museum has a chemical laboratory, 11,537, 11,563, 11,564.
State physiological laboratory desirable; it should be connected with Hunterian Museum, 11,537, 11,566, 11,567.
Laboratories will be provided in new South Kensington Natural History Museum, 11,565.

Lawes, Mr. See *Agriculture.*

Lectures.
Lectures proposed to be given by British Museum keepers of natural history, 11,537.

Magelhan Straits' Expedition. See *Survey Expeditions.*

Minister for Science.
Minister for science, with permanent under secretary and staff, desirable, 11,357, 11,358, 11,545–11,562.

Museum of Practical Geology.
Magelhan Straits' survey collection was sent to Jermyn Street instead of British Museum, 11,541–11,544.
Jermyn Street Museum has competed for fossils that should be placed in British Museum, 11,545.

Museums.
Injury to natural history by existence of competing museums, 11,357.
If all survey collections were sent to British Museum it could supply other museums with specimens, 11,539.
There should be one metropolitan museum for all departments of natural history, 11,546.
See *British Museum.*

Natural History.
Answer to Colonel Strange's evidence relating to British Museum, 11,537.
One metropolitan museum desirable for all departments of natural history, 11,546.

Original Research.
At the British Museum there are rooms with microscopes, &c. for pursuit of research, 11,537.

Physiology.
State physiological laboratory desirable; it should be connected with Hunterian Museum, 11,537, 11,566, 11,567.

Royal College of Surgeons. See *Hunterian Museum.*

Royal Society.
Royal Society should be intrusted with larger funds for science purposes, 11,570–11,573.

Scientific Societies.
A minister for science would have power to apply to the Royal, Linnean, Geological, and other societies, 11,539.

Science.
Promotion of natural history science, 11,535–11,577.
Evil to science of competing State institutions, 11,537, 11,538.
Collections from survey expeditions should all be sent to British Museum, 11,537–11,541.
Minister for science, not a council, desirable, 11,537, 11,538, 11,545–11,562.
For promotion of science, increase of Government Grant desirable, 11,570–11,573.
See *British Museum.*

Sewage.
Experiments are wanting on varieties of grass in relation to sewage and health of towns; they might be undertaken by a Government establishment, 11,574–11,577.

South Kensington.
New natural history museum at South Kensington will contain laboratories, &c., 11,565.

Survey Expeditions.
Survey expeditions should send all specimens to British Museum, 11,537, 11,539.
Magelhan Straits' expedition specimens were sent by Admiralty to Jermyn Street; they should have gone to British Museum, 11,541–11,544.

RICHARDS, Rear-Admiral GEORGE HENRY, C.B., F.R.S. (Index of his Evidence.)

Admiralty.
Admiralty less in want of scientific advice than other departments, but might benefit by a consultative council, 11,582, 11583, 11,591, 11,592.
Admiralty should have an annual sum at disposal for science purposes, 11,597–11,599, 11,633–11,637.
Application to Admiralty for provision for making photographic and spectroscopic observations at Greenwich, 11,599.

Astronomy.
Government should make provision for physical astronomy, separate from Royal Observatory, 11,599, 11,625–11,627.

British Museum.
Majority of Magelhan's Straits' specimens were sent to British Museum, 11,604–11,608.
British Museum does not make the use of specimens which science demands, 11,608–11,611.

Council of Scientific Advice.
A minister for science, and a large paid consultative council, desirable; objections to special committees, 11,580–11,594, 11,612–11,624.
Members of a consultative council should hold office for a considerable number of years, renewable; and have retiring pensions, 11,628–11,632.

Government.
Government promotion of science a public advantage, 11,580–11,654.

Grants for Science Purposes.
Government should grant annually a large sum for science, 11,580–11,654.
Admiralty should be able to give an annual sum for science purposes, 11,597–11,599, 11,633–11,637.

Greenwich Observatory.
Greenwich Observatory an economical establishment; physical astronomy should be separated from it, 11,599, 11,625–11,627.

Hydrographic Office.
Hydrographic Office a great institution, embracing surveys of the whole world; there will always be work for it, 11,638–11,647.

Minister of Science.
Desirability of appointing a minister for science, with a council responsible to him, 11,580–11,594, 11,612–11,632.

Museums.
Specimens collected in Government surveys have been usually forwarded to various museums, 11,595, 11,600–11,611.

Natural History.
Survey natural history collections; usually sent to various museums, 11,595, 11,600–11,611.
Difficult for natural history collections to be made by ships of war, 11,600, 11,601.

Observatories.
Observatories for astronomical physics, &c. desirable; they should be distinct from Greenwich Observatory, 11,599, 11,625–11,627.

Pensions.
Members of a consultative council for science should have retiring pensions, 11,632.

Photography.
Admiralty requested to provide for photographic observations at Greenwich, 11,599.

Physics.
Physical astronomy not provided for by Government; it should be, 11,599.
An observatory for physical astronomy should be separate from, and equal to, Greenwich Observatory, 11,625–11,627.

Science.
Public advantage to be derived from promotion of science by Government, 11,580–11,654.

Scientific Societies.
A minister of science would consult scientific societies as to appointment of a council, 11,628, 11,629.

Spectrum Analysis.
Provision requested of Admiralty for spectroscopic observations at Greenwich, 11,599.

RICHARDS, Rear-Admiral—cont.

Survey Expeditions.
Government should devote funds to surveying expeditions, 11,595.
Natural history specimens, collected by surveys, have usually been sent to different national museums, 11,600–11,611.
Majority of Magelhan Straits' expedition specimens sent to British Museum, 11,604–11,611.
Hydrographical surveys will always be required, 11,638–11,653.
Surveys are usually conducted in the most frequented parts of the ocean; with funds, other places might be explored, 11,649–11,653.

SIEMENS, C. WILLIAM, Esq., D.C.L., F.R.S. (Index of his Evidence.)

Apparatus for Science Purposes.
To the Standards' Department should be added thermometers, barometers, rain-gauges, &c., 11,790.

British Association.
Funds of British Association should be increased by Government, 11,773, 11,774.

Civil Service.
Objection to Civil Service appointments by competitive examination only; heads of departments should select, 11,760–11,768.

Competitive Examinations. See *Examinations.*

Council of Scientific Advice.
Special commissions should advise Government in practical scientific matters; heads of departments, presidents of societies, representatives of universities, &c. might form a council; about 20 required, 11,779, 11,796–11,803, 11,846–11,861, 11,869–11,872.

Degrees.
Original research should be required for higher degrees, 11,815–11,819.

Endowments. See *Professorships.*

Examinations.
Competitive examinations tend to lower mental capacity of students; unsuitable for Civil Service appointments, 11,760–11,768.

Fellowships.
Fellowships should be granted for original research, and with a view to further investigation, 11,769, 11,770, 11,826–11,830.

France.
No independent scientific societies in France of any note, 11,833.

Germany.
Germany has hardly any patent laws; British public suffer from this, 11,781–11,788.
Professors in Germany have good laboratories, large salaries, and opportunity for research, 11,809–11,811.
German system of doctoral dissertations for degrees would be desirable here, 11,815–11,819.
Government promotion of science in Germany is mainly through universities; but some societies have done good work, 11,833–11,844.

Government.
Duty of Government to promote science, 11,755–11,873.
Government scientific institutions should bring their information into a focus, 11,789–11,796.
Government should co-operate with foreign governments for scientific information, 11,781–11,788.

Laboratories.
Objection to establishment of Government laboratories, 11,804–11,807, 11,820–11,825.
More and better equipped laboratories connected with teaching institutions are wanted, 11,805–11,807.
German laboratories are attached to educational institutions, 11,822, 11,825.

Meteorological Department.
Meteorological Department might be advantageously extended, 11,789.

Minister for Science.
Government scientific institutions should be under a minister for science, who need not be a scientific man, 11,790–11,802, 11,846–11,861, 11,869–11,872.

Observations.
Royal observatories should be brought more into juxtaposition with other departments; observatories for physical research wanted, 11,789, 11,804, 11,864–11,868.

Siemens, Dr.—cont.

Original Research.
Government might promote original research by liberally aiding superior professors, learned societies, &c., 11,756–11,759, 11,771–11,779.
Fellowships should be granted chiefly for original research, 11,769, 11,770, 11,826–11,830.
Scientific research should be free; specially appointed discoverers would be in a false position; national laboratories not recommended, 11,803, 11,804.
Original research should be required for higher degrees, as in Germany, 11,815–11,819.
Scientific societies should be able to recommend to Government pensions for scientific investigators, &c., 11,831, 11,832

Patents.
Patent laws provide reward for discoveries, but do not apply to cases of pure science, 11,771.
Desirability of having an international patent law, 11,781–11,788.

Pensions.
Pensions for certain men of science should be recommended to Government by scientific societies, 11,831, 11,832.

Physics.
Observatories for physical research should be instituted by Government, 11,789, 11,804, 11,864–11,868

Printing of Scientific Papers. See *Scientific Publications*

Professors.
Professors eminent for research should be connected with higher teaching, 11,756.
Professors' incomes should be largely increased, 11,862, 11,863.

Professorships.
Government could best promote science by liberal endowment of professorships, 11,756–11,759, 11,862, 11,863.

Salaries.
Salaries of professors should be largely increased, 11,756–11,759, 11,862, 11,863

Science.
Science should be promoted by Government, by liberal endowment of chairs, aid to scientific societies, appointment of commissions, &c., 11,755–11,873.

Scientific Publications.
Government should aid scientific societies in publishing their proceedings, 11,775–11,778.
Results of all the Government scientific departments should be collected and published by a special department of publication, 11,790–11,794.

Scientific Societies.
Scientific societies; should be more aided by Government; might undertake special inquiries for Government, &c., 11,771–11,779, 11,808–11,814, 11,831, 11,832.
Scientific societies in Germany and France are not comparable to those of England, 11,833–11,841.

Standards' Department.
Standards' Department should be extended; thermometers, barometers, &c. should be added, 11,790.

Students.
Mental capacity of students lowered by competitive examinations, 11,760.

Telegraphs.
A Government institution for telegraphs should be instituted, 11,790, 11,871.

Universities.
Government should promote science by liberal endowment of university chairs, 11,756–11,759.
State promotion of science in Germany is mainly through universities, 11,833, 11,841.

STRACHEY, Major-General, F.R.S. (Index of his Evidence.)

Astronomy.
Astronomical observations in India are made only at Madras, 11,893

British Museum.
Want of connexion between British Museum and Parliament, 11,878, 11,879.

Civil Service Commission. See *Examinations.*

Colonies.
Scientific administration in the colonies might be controlled by a State council of scientific advice, 11,890.

Strachey, Major-Gen.—cont.

Council of Scientific Advice.
A scientific council to advise Government desirable; nine members sufficient; it should have freedom of action, and be unpaid at first; it should not control public money; objection to *ex officio* members, 11,879–11,916.

Education Department.
Education Department the most suitable to deal with Government scientific matters; it might have a branch for science, with permanent under secretary, 11,875–11,878.

Examinations.
Officers for a Government scientific department should not be chosen after a mere pass Civil Service examination, 11,876.

Government.
Government should promote science; closer connexion with scientific departments essential, 11,875–11,879.

Grants for Science Purposes.
A council of scientific advice should not be entrusted with public money, 11,889.
Objection to the 1,000*l.* grant being controlled by Royal Society, 11,889, 11,890.
England should make grants to India for science purposes, 11,893.

India.
Difficulties of Indian Government in relation to science; Government might aid India through a scientific council, &c., 11,890–11,893, 11,916.
No weights or measures defined by law in India; want of a uniform system, 11,891.
India the best place for promotion of meteorological science, 11,893.
Astronomical observations in India; made only at Madras Observatory, 11,893.

Laboratories.
Necessity for institution of Government laboratories, physical, physiological, &c., 11,884.

Meteorology.
Meteorological science; its importance to India, the best place for its promotion, 11,893.

Minister for Science.
Separate department for science not desirable; Government scientific matters might be controlled by Minister of Education, 11,875–11,916.

Observatories.
Necessity for institution of observatories by Government, 11,884.
Madras Observatory the only one in India where astronomical observations are taken, 11,893.

Office of Works.
Scientific institutions might be under Office of Works as to buildings, &c., but not as to administration, 11,878.

Royal Society.
Royal Society not the best scientific adviser for Government, 11,886.
Objection to Government money being entrusted to Royal Society for science purposes, 11,889, 11,890.

Science.
Improved relation between scientific departments and Government essential, 11,875–11,916.
Separate science department not wanted; Education Department might have a science branch, with permanent under secretary, &c., 11,875–11,916.

Scientific Societies.
A council of scientific advice might organize independent scientific societies, 11,893, 11,894.

Weights and Measures.
Want of a uniform system of weights and measures in India, 11,891.

ANDERSON, JOHN, Esq., LL.D., C.E. (Index of his Evidence.)

Artizans.
Numerous science examination papers are sent in by ploughmen, 11,963–11,969.

Council of Scientific Advice.
A small science council, with low salaries, and meeting occasionally, might best advise Government; it should be under Education Department, 11,925–11,946, 11,959–11,962.

Education Department.
A council for science should be under Education Department, with scientific permanent secretary, &c., 11,946, 11,959–11,962.

ANDERSON, Dr.—cont.

Examinations.
- Examinations in science should be tested by the scientific, not literary, knowledge shown, 11,963–11,969.
- Science examination papers sent in by ploughmen, &c., 11,963–11,969.

Forfarshire.
- Numerous cases in Forfarshire of science examination papers being sent in by ploughmen, 11,963–11,969.

Government.
- Scientific investigations of iron, fuel, &c. should be undertaken by Government, 11,925–11,962.

Laboratories.
- A grand national laboratory (comprising chemical, physical, and physiological laboratories) desirable, all being under one head, administrative, not scientific, 11,933–11,936, 11,947–11,956.

Metallurgy.
- Necessity for investigating properties of iron, alloys, &c.; one or two investigators, with laboratory, apparatus, &c., should be appointed by the State, 11,930–11,943.

Original Research.
- Government scientific officers are too overworked to pursue original research, 11,933, 11,944.
- No systematic pursuit of original research at Woolwich Arsenal, 11,727, 11,948, 11,957.

Schools.
- In examinations of science schools, scientific rather than literary ability should be looked for, 11,963–11,969.

Science.
- Small committee preferable to a council for giving scientific advice to Government, 11,925–11,930.
- Working out of chemical and physical properties of iron, fuel, &c., desirable; Government should undertake this, 11,925–11,932, 11,943.
- War Department; superior scientific knowledge of its officers, 11,926–11,928.
- Science more important than literature in examination papers of science schools, 11,963–11,969.

War Department.
- Scientific knowledge in War Department sufficient for most of its purposes, 11,926–11,928.

Woolwich.
- Woolwich not a desirable locality for a great national laboratory, 11,948.
- No systematic pursuit of original research in Woolwich Arsenal, 11,927, 11,957.

SPOTTISWOODE, WILLIAM, Esq., F.R.S. (Index of his Evidence.)

Astronomy.
- Extension of Greenwich Observatory, for solar physics, &c., desirable, 11,990, 11,993.

Council of Scientific Advice.
- Importance of instituting a Government scientific council; but a smaller scheme might be proposed to begin with, 11,972, 11,973.
- Council of science; members (with some *ex officio*) should be appointed by minister, for long periods, not for life; they will have to be paid; council might appoint special committees; it should have a permanent scientific under secretary, 11,972–12,040.
- Government, before appointing a scientific council, might ascertain if Royal Society could aid it, 11,979–11,987.
- Inquiries within the competency of departments should not be initiated by a council of science, 11,986, 12,000–12,004.
- A State council of science would probably be mainly composed of fellows of the Royal Society, 12,038.

Government.
- Government aid to science; its difficulty in deciding applications; its want of a scientific council, 11,972–12,040.

Grants for Science Purposes.
- Government grant to Royal Society might be extended, but extension should arise out of demand, 11,995.
- Necessity for a scientific body standing between applicants for grants and Government who makes grants, 11,995–11,999.

Greenwich Observatory.
- Greenwich Observatory might be extended, to take in solar physics, &c., 11,990, 11,993.

India Office.
- Appointments of India Office Council a model for those of a scientific council, 11,977.

SPOTTISWOODE, W., Esq.—cont.

Laboratories.
- Establishment of national laboratories advantageous, but larger grants to existing institutions might effect much, 11,989, 11,990, 11,994.

Observatories.
- In view of expense, extension of existing observatories would be preferable to establishment of new ones, 11,990–11,993.

Royal Society.
- Government might ascertain if Royal Society could aid it; if not, a separate scientific council might be formed, 11,979–11,987, 12,018, 12,019.
- Extension of Royal Society Government grant desirable, but it should first arise out of demand, 11,995.
- A Government council of science would be mainly composed of fellows of Royal Society, 12,038.

Science.
- Promotion of science by Government; importance of Government appreciation of science; statesmen should be educated in science, 11,972–12,040.

SCLATER, PHILIP LUTLEY, Esq., M.A., Ph.D., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
- Government should grant more assistance to scientific societies in respect to provision of rooms, 12,127–12,134.

Army.
- Heads of scientific branches of the Army might be members of a State consultative council for science, 12,046, 12,086.

Austria.
- In Austria, natural history collectors are trained and sent round the world by the government, 12,126.

British Museum.
- British Museum should receive all collections of State surveys; it might then send specimens to other institutions, 12,104–12,121, 12,135–12,137.
- Specimens at British Museum are chiefly bought from dealers; a great defect, 12,122–12,124.
- British Museum should have skilled naturalists always ready to act as collectors on State expeditions, 12,125, 12,126.
- Insufficient staff for zoology at British Museum, 12,137.

College of Surgeons. See *Scientific Institutions.*

Council of Scientific Advice.
- State council for science, under Minister of Education, desirable; heads of scientific institutions and private societies might be members, with moderate salary; it should publish annual reports; it should control all State scientific institutions; members should hold office five or ten years, with possibility of re-appointment, 12,042–12,096.

France.
- Natural history collectors for surveying expeditions are purposely trained in France 12,126.

Government.
- State should promote science by forming a scientific council, assisting private scientific societies, &c., 12,042–12,137.

Minister for Science.
- Minister specially for science could hardly be expected; a scientific council might be controlled by Minister of Education, 12,044, 12,045.

Museums.
- Local museums might be supplied with natural history specimens by British Museum, if it received all survey collections, 12,104–12,121, 12,135–12,137.
  See *British Museum.*

Natural History.
- Naturalists should be attached to all Government survey expeditions, 12,097–12,103.
- Want of trained natural history collectors, like those of Germany and France, for surveying expeditions, 12,125, 12,126.
  See *British Museum.*

Navy.
- Navy scientific departments might be represented by their directors in a consultative council, 12,046, 12,086.

Science.
- Government should aid science by forming a council, providing naturalists for surveys, assisting scientific societies, &c., 12,042–12,137.

Sclater, P. L., Esq.—cont.

Scientific Institutions.
Heads of State scientific institutions might form a consultative council; representatives of College of Surgeons, Army and Navy, &c. might be added, 12,046.

Scientific Societies.
Nominees of leading scientific societies might be members of a State science council, 12,090.
Importance of scientific societies; Government should aid them (especially the poorer societies) with rooms, 12,127–12,134.

Survey Expeditions.
Every surveying vessel sent out by Admiralty should have a naturalist attached, 12,097–12,102.
Naturalists should be trained at British Museum to go out with State expeditions, 12,125, 12,126, 12,135.

Zoology.
Zoological Society's Museum was dispersed, after being offered to British Museum, 12,119–12,121.
See *Natural History.*

HOOKER, JOSEPH DALTON, Esq., M.D., C.B., F.R.S. (Index of his Evidence.)

Boards of Visitors.
Boards of visitors desirable for every State scientific institution; should be chiefly scientific bodies, with Members of Parliament, &c. having appreciation of science, 12,138–12,184, 12,188.

Botany.
More might be done at British Museum and Kew in regard to botany, 12,186.
Aid wanted for researches in chemical botany, &c. at Kew, 12,190–12,194.

British Museum.
Natural history museum, when removed, should be under a director responsible to a minister, and be more useful to science, 12,186.

Council of Scientific Advice.
State council for science too extensive a scheme to be likely of success; boards of visitors desirable at first; a general council might be called together occasionally, and not made permanent, 12,138–12,184.

Government.
Government promotion of science; its action should be more systematic; it should have scientific advisers, 12,138–12,194.

Grants for Science Purposes.
Government grants frequently withheld from want of confidence as to their necessity, 12,172.
Grants wanted to induce experimenters to prosecute research at Kew, 12,190–12,194.

Greenwich Observatory.
Boards of visitors, like those for Greenwich, desirable for every State scientific institution, 12,138–12,184.

Kew.
More might be done at Kew in regard to botany, 12,186.
Funds should be provided to aid prosecutors of original research at Kew, 12,190–12,194.

Minister of Education.
A minister of education and science is much wanted, 12,166–12,172.

Natural History. See *British Museum.*

Original Research.
Desirability of aid being given to prosecutors of original research at Kew, 12,190–12,194.

Science.
Science should be promoted by the State; a more systematic action essential, 12,138–12,194.
Little done for advancement of science by general public; a great deal has been done by a few, 12,155.

Scientific Institutions.
Desirable that every State scientific institution should have a board of visitors, to whom Government might apply, 12,138–12,184.

GRANT, ROBERT, Esq., LL.D., F.R.S. (Index of his Evidence.)

Admiralty.
Admiralty should not be under control of a council for science, 12,256.

Astronomy.
Astronomical science at Glasgow University; inadequate salary of professor; want of funds for assistants, printing observations, &c., 12,266–12,290.

Grant, Prof.—*Astronomy*—cont.
A star catalogue should be undertaken by several observatories, with a central body for communication, 12,271–12,278.
Astronomical physics should be promoted by Government, by aiding private research, not instituting a laboratory, 12,279–12,283.

Boards of Visitors.
Approval of Greenwich Observatory board of visitors; it should not be interfered with, 12,253, 12,254.

Contributions for Science Purposes.
Private contributions for science would result if Government took the initiative, 12,230, 12,231, 12,267.
See *Grants for Science Purposes.*

Council of Scientific Advice.
Council for science desirable; a small number of permanent officials sufficient; its duties might be confined to grants for secondary schools, scientific societies, private research, &c.; Admiralty, &c. should be exempted from its control, 12,245–12,260, 12,274.

Endowed Schools' Commission.
Proposed scientific instruction in schools under Endowed Schools' Commission is insufficient, 12,203.

Germany.
Science more promoted in Germany than in England; conditions of society there more favourable, 12,197, 12,198.

Glasgow University.
Efficient state of physical laboratory at Glasgow University, 12,208, 12,209.

Government.
Government should aid in the promotion of science, 12,195–12,290.

Grants for Science Purposes.
State grants for science should be given to secondary schools, higher educational institutions, private investigators, &c., 12,204–12,213.
Royal Society Government grant should be increased and made better known; separate grant for Scotland undesirable, 12,213–12,225, 12,258–12,260.

Greenwich Observatory.
Greenwich Observatory board of visitors has worked well; it should not be altered, 12,253, 12,254.

Laboratories.
State aid should be given to laboratories in higher educational institutions, 12,207.
Physical laboratory at Glasgow University is in a most efficient state, 12,208, 12,209.
Lectures should be combined with laboratory work, 12,237–12,244.

Languages.
Secondary schools should teach modern languages; doubtful if Government should aid languages; these are mostly provided for, 12,261–12,263.

Lectures.
Desirable that every scientific professor should give public lectures, 12,237–12,243.

Ordnance Survey.
Ordnance Survey should not be under control of a council for science, 12,256.

Original Research.
Public mind insufficiently educated to appreciate scientific research, 12,197, 12,198.
State aid should be given for promotion of research to higher educational institutions, private persons, &c., 12,207, 12,213, 12,237–12,244.
Government should aid private research in astronomical physics, 12,279–12,283.

Owens College.
Owens College a type of the higher educational institutions; it should be aided by the State, 12,199–12,201.

Professors.
Professors in scientific institutions should have State aid; they should give lectures and pursue research, 12,207, 12,237–12,244.
Glasgow University professor of astronomy; his inadequate salary, &c., 12,266–12,290.

Professorships.
Professorships in higher educational institutions should be aided by Government, 12,207, 12,237–12,244.
Chair of astronomy at Glasgow University; its inadequate endowment, &c., 12,266–12,290.

Royal Society. See *Grants for Science Purposes.*

Grant, Prof.—*cont.*
Schools.
Secondary schools giving scientific instruction are essential; they should have State aid; wanted both in Scotland and England, 12,201–12,212.
Endowed schools do not give sufficient prominence to science, 12,203.
Modern languages should be taught in secondary schools, 12,261–12,263.
Science.
Promotion of science by the State; aid should be given to educational institutions, private investigators, &c., 12,195–12,290.
A comprehensive scheme for science undesirable; demand for it does not exist, 12,196.
More satisfactory condition of science in Germany than in Britain, 12,197, 12,198.
Science must be advanced by close connexion with educational institutions, 12,199, 12,200.
Promotion of science in Scotland; want of science teaching in schools, 12,201–12,212, 12,223, 12,224.
Secondary schools for teaching science are essential, 12,201–12,212.
Unsatisfactory relation between scientific societies and Government, which should support them, 12,226–12,236.
Private contributions for science would result from Government taking the initiative, 12,230, 12,231, 12,267.
Astronomical science at Glasgow; State aid required for astronomical physics, 12,266–12,290.
Council for science, confined to grants for schools, research, &c., desirable, 12,245–12,260, 12,274.
See *Original Research.*
Scientific Publications.
Annual sum required for printing astronomical observations at Glasgow, 12,284.
Scientific Societies.
All scientific societies should receive some national support; they would then increase in number, 12,226–12,236.
Scotland.
Want of secondary schools teaching science in Scotland, 12,201–12,212.
Separate grant for science (like Royal Society Government grant) not necessary for Scotland, 12,223, 12,224.
Universities.
Universities suffer from want of scientific teaching in schools, 12,201–12,212.
Woolwich.
Government establishments at Woolwich should not be under control of a scientific council, 12,256.

SANDERSON, J. S. BURDON, Esq., M.D., F.R.S. (Index of his Evidence.)

Apparatus for Science Purposes.
Grants should be made for apparatus for physiological research, 12,302–12,305, 12,322.
Austria.
In Austria, assessors on scientific subjects communicate with minister of education, 12,355, 12,356.
Brown Institution.
Brown Institution has a pathological laboratory; it is not connected with a medical school, 12,323, 12,324.
Council of Scientific Advice.
Necessity for a council of science; scientific members should be skilled in research; number should be few, and remuneration considerable; council should be subject to a minister, 12,344–12,356.
Edinburgh University.
Edinburgh University physiological laboratory should be aided by grants, 12,304.
Examinations.
Evils of examinations for honours to students of research, 12,300, 12,301, 12,305.
Germany.
Research in physiology, &c. more successful in Germany than in England, 12,294–12,301, 12,311, 12,326–12,333.
Numerous teaching appointments open to scientific students in Germany, 12,302, 12,334.
Grants for Science Purposes.
Grants should be made for laboratories, instruments, and workers, in physiology, &c., 12,302–12,305, 12,322, 12,325–12,337.

Sanderson, Dr.—*Grants, &c.*—cont.
Wherever an efficient laboratory and an efficient worker exists, there is a case for a grant, 12,322.
Honours. See *Universities.*
Laboratories.
Money should be devoted to improvement of laboratories for physiology, &c., 12,302 12,305, 12,322.
A physiological laboratory must be in connexion with the great schools of medicine, 12,302.
Brown Institution has a pathological laboratory, 12,323, 12,324.
Manchester.
The best provincial school for teaching physiology is at Manchester; it should be aided by grants, 12,302–12,305.
Medicine.
Connexion essential between medical science and physiological research, 12,294–12,296, 12,302, 12,307–12,343.
University honours in medicine are a mistake, 12,300, 12,301.
The four largest medical schools in London, also those in Edinburgh, Manchester, &c., should be assisted by grants, 12,302 12,305.
Inefficient teaching of physiology in medical schools, 12,335–12,343.
Want of a central scientific school for the various medical schools, 12,338–12,342.
Minister of Education.
A council of science might be placed in relation to a minister of education, as in Austria, 12,355, 12,356.
Original Research.
Research in physiology must be carried out by students and teachers of medicine, 12,294–12,296.
University honours should be given for original research, not book-work, 12,300, 13,301, 12,305.
In a scientific council, the members should be original investigators, 12,344.
Pathology.
Brown Institution, with a pathological laboratory, is confined to researches upon disease, 12,323, 12,324.
Physiology.
Physiologists (formerly merely physicians or surgeons) must now be chemists and physicists, 12,294–12,296.
Physiological research and medical science must be connected, 12,294–12,296, 12,307–12,343.
Impediments to physiological research in tendency of public opinion, competition for book-work honours, &c., 12,297–12,301.
For promotion of physiology, &c., grants should be made for laboratories, apparatus, and workers, 12,302–12,305, 12,322, 12,325–12,337.
A physiological laboratory must be connected with the great schools of medicine, 12,302.
Imperfect system of teaching physiology in medical schools; bad remuneration of teacher, 12,335–12,343.
Professors.
Medical professors (and their students) are the proper persons to pursue investigations in physiology, 12,294–12,296.
Grants desirable to induce teachers to continue a scientific career, 12,302–12,305, 12,322, 12,325–12,337.
Schools.
Physiology should be taught as a branch of general education in schools, 12,312–12,319.
See *Medicine.*
Science.
Promotion of physiological science, 12,294–12,356.
A State council of science desirable, 12,344–12,356.
Students.
Students of medicine (with their teachers) are the proper persons to carry out physiological research, 12,294–12,296.
Impediments to students engaging in scientific careers; evil of competition for honours, &c., 12,297–12,301, 12,305.
Students should do original work for gaining university honours, 12,306.
Students of physiology need not necessarily become physicians, 12,307 12,309.
Competent students working out research should be aided by grants, 12,302–12,305, 12,322, 12,325–12,337.
Teachers. See *Professors.*
Universities.
Evil of University honours being given for book-work instead of research, 12,300, 12,301, 12,306.

BUCHAN, ALEXANDER, Esq., F.R.S.E. (Index of his Evidence.)

Apparatus for Science Purposes.
- Apparatus furnished by Scottish Meteorological Society to their stations; many stations lost for want of instruments, 12,368-12,370, 12,379, 12,387, 12,392, 12,412, 12,413.
- Different arrangement of thermometers by Meteorological Committee and by Scottish Meteorological Society, 12,412.

Government.
- Government does not aid Scottish Meteorological Society now, 12,379, 12,383, 12,389, 12,410.

Grants for Science Purposes.
- Grants wanted by Scottish Meteorological Society, for its general efficiency, publications, &c., 12,379, 12,383, 12,389, 12,410.

Meteorology.
- Meteorological observations in Scotland, 12,357-12,414.
- Instruction in meteorology given in Scottish schools, 12,411.
  - See *Scottish Meteorological Society.*

Meteorological Committee (Board of Trade).
- Meteorological Committee's observations are continuous registration: Scottish Meteorological Society's are eye observations, 12,407, 12,412, 12,414.

Observatories.
- Two fully-equipped meteorological observatories wanted in Scotland, to supplement stations of Scottish Meteorological Society, 12,413.
  - See *Meteorology.*

Original Research.
- Funds wanted by Scottish Meteorological Society for carrying out special researches, 12,404.

Registrar General.
- Scottish Meteorological Society supplies observations to Registrar General, 12,387-12,391.

Schools.
- Meteorological instruction given in schools in Scotland, 12,411.

Science.
- Meteorological science in Scotland, 12,357-12,414.

Scientific Publications.
- Quarterly journal of Scottish Meteorological Society; highly esteemed by foreigners, &c.; funds wanted to increase it, 12,395-12,398.

Scottish Meteorological Society.
- Scottish Meteorological Society; has upwards of 90 stations; valuable apparatus; no paid observers; not assisted by Government; publishes a quarterly journal; funds wanted, 12,357-12,414.

MILNE-HOME, DAVID, Esq., LL.D., F.R.S.E. (Index of his Evidence.)

Accommodation for Science Purposes.
- Royal Society of Edinburgh has poor and shabby accommodation, 12,467, 12,493.

Agriculture.
- Agricultural chemistry formerly taught in Scottish schools, 12,460.
- Advantage of meteorology in reference to agriculture; its encouragement by Highland and Agricultural Society, &c., 12,503-12,509, 12,528-12,530.
- German and French institutions for advancing science of agriculture, 12,530-12,533.
- Government farms attached to certain schools in Ireland, 12,532.

Apparatus for Science Purposes.
- Approval of Royal Society's grant being made for purchase of apparatus, 12,499.
- Apparatus formerly furnished by Government to Scottish Meteorological Society, 12,517-12,521.

Artizans.
- Scientific knowledge of Scottish working men; important researches made by them, 12,423-12,428.
- Edinburgh Geological Society is mostly composed of artizans, 12,535-12,538.

Bursaries.
- Many bursaries at Glasgow, Aberdeen, &c. for poor students, 12,461.

Canada.
- Meteorological instruction given in Canadian schools, 12,514.

MILNE-HOME, D., Esq.—cont.

Chemistry.
- Teaching of agricultural chemistry formerly in Scottish schools, 12,460.

Council of Scientific Advice.
- A State council of scientific advice desirable; it should be in London, with committees in Ireland and Scotland, 12,446-12,459.

France.
- Instruction in meteorology given in many French schools, 12,514.
- Several institutions in France for teaching principles of agriculture, 12,533.

Geological Society (Edinburgh).
- Edinburgh Geological Society; members mostly of working class; want of funds, 12,425-12,427, 12,535-12,538.

Geology.
- Interest taken in geology by Royal Society of Edinburgh, 12,482, 12,483.

Germany.
- In Germany funds exist for passing poor scholars into higher schools, 12,460-12,465.
- More important scientific discoveries made in Germany than in England, 12,471-12,473.
- Promotion of agricultural science in Germany, 12,530, 12,531.

Government.
- Government aid to science wanted in Scotland, 12,420-12,457.

Grants for Science Purposes.
- Government grant of Royal Society; not sufficiently known in Scotland; approval of its being made for apparatus and assistants, 12,434-12,442, 12,499, 12,547.
- State grants wanted in Scotland for original research, poor scholars, Scottish Meteorological Society, Edinburgh Geological Society, &c., 12,446-12,467, 12,474-12,530.

Health.
- Importance of Scottish Meteorological Society's observations in relation to public health, 12,505, 12,528.

Highland and Agricultural Society of Scotland. See *Agriculture.*

Ireland.
- Farming instruction in connexion with Larne and Glasnevin schools in Ireland, 12,530.
- Advantages of Royal Society Government grant should be better known in Ireland, 12,442.
- Large grants for science, &c. given to Ireland, as compared with Scotland, 12,547.

Meteorology.
- Meteorological instruction given in many Scottish schools; also in schools of Canada and France, 12,460, 12,513, 12,514.
  - See *Scottish Meteorological Society.*

Natural History
- Natural history instruction given in Scottish parochial schools, 12,423.

Original Research.
- Scottish scientific societies are much engaged in research; they want aid, 12,423, 12,429-12,443.
- Important original researches in botany, geology, &c. made by Scottish working men, 12,423-12,428.
- Scottish universities but little promote original research, 12,443.
- Money grants for research should be made through a scientific council, 12,446-12,459.
- Necessity for promotion of original research in connexion with agriculture, 12,530.

Professorships.
- Foundation of Edinburgh Chair of Geology by Sir R. Murchison and Government, 12,482.

Rainfall.
- Planting of forests to secure greater rainfall, 12,508, 12,509.

Registrar General.
- Registrar General of Scotland receives returns from 55 stations only of Meteorological Society; additional returns required, 12,505, 12,521-12,523.

Royal Society of Edinburgh.
- Royal Society of Edinburgh gives small aid to research; with members of other societies it might advise a scientific council as to grants, &c.; it should have funds for aiding science in Scotland, 12,425-12,433, 12,446-12,459, 12,467, 12,474-12,500.

MILNE-HOME, D., Esq.—cont.

Schools.
Science teaching in parochial schools of Scotland; agricultural chemistry formerly taught, 12,423, 12,460.
Meteorology taught in schools of Scotland, Canada, &c., the schoolmasters being observers, 12,461, 12,513, 12,514.
Great want in Scotland of means to enable poor scholars to go into higher schools, 12,460–12,465.

Science.
Promotion of science in Scotland; not specially encouraged in schools, 12,420–12,547.
Scientific discoveries of Germany more important than those of England, 12,471–12,473.
Increase of public wealth has not much increased contributions to science, 12,539–12,547.

Science and Art Department.
Regulations of Science and Art Department are imperfectly known in Scotland, 12,462, 12,463.

Scientific Publications.
Want of funds to publish transactions of Scottish scientific societies, 12,422–12,442, 12,466, 12,485, 12,495, 12,515, 12,516.

Scientific Societies.
Valuable scientific societies in Scotland; Government should aid in publication of their transactions, &c., 12,422–12,442, 12,446, 12,485, 12,495, 12,515, 12,516.

Scotland.
Promotion of science in Scotland, 12,420–12,547.
Royal Society Government grant is not sufficiently known in Scotland, 12,434–12,442, 12,499, 12,547.
Scotland might have a board for science, in communication with a scientific council in London, 12,446–12,459.
General feeling in Scotland that the public has done enough for science, and Government too little, 12,539–12,546.
Scotland wants means to enable poor scholars to pass into higher schools, 12,460–12,465.
Grants to Ireland for science, &c. are four times greater than to Scotland, 12,547.

Scottish Meteorological Society.
Meteorological Society of Scotland; it has 90 stations; important to health, agriculture, forests, &c.; it should have Government aid, 12,501–12,530, 12,540.

Students.
Means are wanting in Scotland to enable poor students to obtain a higher education, 12,460–12,465.
There are many bursaries for poor students in Scotland, 12,461.

Universities.
Scottish universities have but little promoted research, but they have set apart laboratories, &c., 12,443.

RAWLINSON, MAJOR-GENERAL SIR HENRY C., K.C.B., &c. (Index of his Evidence.)

Accommodation for Science Purposes.
Deficient accommodation of Royal Geographical Society; place for meeting wanted; hall of London University lent to society; no space allotted in Burlington House, 12,592–12,598.
Accommodation provided in Burlington House for Geological, Linnean, Astronomical, Chemical, and Antiquaries Societies, 12,598–12,600.

Admiralty.
Admiralty should not be controlled by a council of science, 12,563, 12,564.

Apparatus for Science Purposes.
Use of sextant, theodolite, &c. proposed to be taught to travellers by Royal Geographical Society, 12,603.

Burlington House. See *Accommodation for Science Purposes.*

Council of India.
Council of India; variety of scientific questions referred to it; council comprises 15 members; a precedent for a consultative council of science, 12,558–12,587.

Council of Scientific Advice.
Necessity for a permanent scientific council; 15 members sufficient; they should have 500*l.* a year, be under Minister of Education, and should give only part of their time, 12,552–12,587.

Examinations.
University examinations for certain public schools are to include geography, 12,605, 12,610–12,612.

RAWLINSON, Major-Gen. Sir H.—cont.

Geography.
Promotion of geographical science, 12,548–12,619.
See *Royal Geographical Society.*

Government.
Relation of Government to Royal Geographical Society, 12,548–12,552, 12,588–12,608.
Government should have for adviser a permanent scientific council, 12,552–12,587.

Grants for Science Purposes.
Survey expeditions received large Government grants formerly; applications latterly declined, 12,549–12,551.
Royal Geographical Society has a grant of 500*l.* a year; further aid for buildings wanted, 12,588–12,601.
See *Income and Expenditure.*

Greenwich Observatory.
Greenwich Observatory should be controlled by a council of science, 12,563.

Income and Expenditure.
500*l.* a sufficient salary for each member of a State scientific council, 12,553, 12,582.
Royal Geographical Society has 5,000*l.* to 6,000*l.* a year; it subscribes largely for expeditions, &c., 12,606–12,608.
See *Grants for Science Purposes.*

India.
Great variety of scientific questions arising in India, 12,565.
See *Council of India.*

Lord President. See *Minister of Education.*

Minister of Education.
Minister of Education (the Lord President) might act with a consultative council of science, 12,552–12,587.

Ordnance Department.
Experiments carried on by Ordnance Department need not be controlled by a scientific council, 12,563, 12,564.

Royal Geographical Society.
Royal Geographical Society; its advice to Government; its value to travellers, &c.; its want of meeting room; its geographical prizes for schools; its income, journals, &c., 12,548–12,557, 12,588–12,619.

Schools.
Royal Geographical Society's prizes for schools; 11 leading schools competed this year, Eton and Liverpool carrying off all the prizes, 12,605, 12,610–12,619.
Geography should form part of school, rather than university, education, 12,611, 12,612.

Science.
Promotion of geographical science, 12,548–12,619.
No necessity for creating a special ministry of science; a council sufficient, 12,552–12,587.
Variety of scientific questions arising in India, 12,565.
See *Council of Scientific Advice.*

Scientific Publications.
Journal of Royal Geographical Society; published regularly since 1830; its great value, 12,609.
See *Text Books.*

Scientific Societies.
Burlington House is to accommodate the Linnean, Geological, and other societies, but not the Royal Geographical Society, 12,598–12,600.

Survey Expeditions.
Survey expeditions; their promotion by Royal Geographical Society; uncertain action of Government respecting them, 12,549–12,551, 12,608.

Text Books.
Defects in manuals of geography; preparation of a manual contemplated by Royal Geographical Society, 12,613–12,616.

Universities.
Universities are to include geography in their examinations for certain public schools, 12,605, 12,610.

FARRER, THOMAS HENRY, Esq. (Index of his Evidence.)

Alkali Works.
Alkali works; controlled by Board of Trade; inspected by Dr. Angus Smith and staff, 12,623–12,631.

Board of Trade.
Board of Trade; its functions and relation to science; its regular scientific staff, employment of special persons, &c., 12,620–12,703.

Cambridge University. See *Universities.*

Farrer, T. H., Esq.—cont.

Council of Scientific Advice.
State council for science desirable; it should be paid, independent of Government, appointed by Royal Society, responsible to Minister of Education, and should initiate inquiries, 12,634–12,661, 12,671–12,673, 12,676.

Electricity.
Electric light for lighthouses; experiments of Professors Faraday, Tyndall, &c. for Board of Trade, 12,623–12,631.

Endowments.
University endowments should be devoted to promotion of science, 12,674–12,678.

Fellowships.
Fellowships at Oxford do not tend to promote scientific research, 12,677, 12,678.

Fisheries.
Control of fisheries by Board of Trade; natural history questions arising therefrom, 12,622–12,631.

Gas.
Board of Trade has control over gas, as to supply and purity, in London; also in lighthouses, &c., 12,623–12,631, 12,637.

Government.
Government should have a consultative council for science, 12,634–12,661, 12,671–12,673, 12,676.

Grants for Science Purposes.
State grants for science; Meteorological Office grant; proposals for increased grants should be considered by a council of science; there should be a responsible officer for keeping the accounts, 12,639–12,642, 12,661–12,668.
See *Endowments.*

Harbours.
Scientific matters relating to harbours come under control of Board of Trade, 12,622–12,631.

Lighthouses.
Control of lighthouses by Board of Trade; experiments on electric light, introduction of gas, &c., 12,622–12,631.

Meteorological Office.
Meteorological Office; its connexion with Royal Society and Board of Trade; desirability of having a scientific council to refer to respecting it, 12,639–12,642, 12,661–12,666.
See *Scottish Meteorological Society.*

Minister of Education.
A State council of science might be subject to the Minister of Education, 12,673.

Natural History.
Natural history questions as to fisheries, &c. come under Board of Trade, 12,622–12,631.

Navigation.
Health of crews and passengers in ships, deviation of compasses, &c., come under inspection of Board of Trade, 12,622–12,631.

Original Research.
State scientific council desirable to advise upon and initiate questions of research, 12,634–12,638, 12,642–12,646.
State assistance should be given in aid of private research, 12,642.
Original research is not promoted by Oxford fellowships, 12,677, 12,678.

Oxford University. See *Universities.*

Railways.
Board of Trade inspection and control of railways, 12,622–12,631.

Royal Society.
Meteorological Office is controlled by an unpaid committee of the Royal Society, 12,639–12,642, 12,661–12,666.
Royal Society, or a committee of the same, would form the best State scientific council, 12,643, 12,644.

Science.
Great variety of scientific matters under control of Board of Trade, 12,620–12,703.
State scientific council desirable, 12,634–12,661, 12,671–12,673, 12,676.
Desirability of applying university endowments to purposes of science, 12,669, 12,674–12,678.

Farrer, T. H., Esq.—cont.

Scottish Meteorological Society.
Scottish Meteorological Society refused aid by Treasury, 12,641.

Standard Weights and Measures.
Supervision of standard weights and measures by Board of Trade, 12,622–12,631.

Waterworks.
Control of London water-supply, as to purification, &c., by Board of Trade, 12,623–12,631, 12,637.

Weights and Measures. See *Standard Weights and Measures.*

Universities.
Oxford and Cambridge Universities have latterly promoted science; they should do so a great deal more, 12,669, 12,674–12,678.

WILLIAMSON, ALEXANDER W., Esq., Ph. D., F.R.S. (Index of his Evidence.)

Council of Scientific Advice.
State council for science (subject to a minister) desirable; it should publish reports; five or six members sufficient, appointed for 12 or 15 years; it should not initiate inquiries, 12,680–12,703.

Examinations.
Examinations are no test for higher scientific work; reports of competent persons must decide, 12,682.

Germany.
Centralization of administration of science desirable, as in Germany, 12,681.

Government.
Government aid to science essential, 12,680–12,703.

Laboratories.
Inadvisable to establish national laboratories for research, 12,696.

Minister of Education.
Minister for science and education essential; there should be a scientific council to report to him, 12,681, 12,690, 12,691.

Original Research.
Importance to science of close union of functions of teaching and original research, 12,682, 12,696.
Government should aid private promoters of research, 12,682, 12,698.
National laboratories for research not advisable, 12,696.
Schools should be encouraged to develope research, 12,696.

Schools.
In all schools poor youths of special scientific ability should be aided by the State, 12,682.
Aid should be given to schools to encourage promotion of original research, 12,696.

Science.
A council for science desirable; it should not advise in matters of applied science, 12,680–12,705.
Better system of scientific education wanted, 12,681–12,682.
Original research should be aided by the State, 12,682, 12,696, 12,698.
Poor scholars of special scientific capacity should be aided by the State, 12,682.

Scientific Publications.
A State scientific council should publish annually a complete report of national resources available for science, 12,681, 12,687.

Students.
Importance of State aid being given to enable clever scientific students to continue their studies, 12,682.

Universities.
For promotion of science, system of control over universities, &c. is wanted, 12,681, 12,682.

REED, EDWARD J., Esq., C.B. (Index of his Evidence.)

Admiralty.
Admiralty scientific matters; important questions undeveloped; "Captain" not lost through want of scientific knowledge, 12,706–12,723.

Board of Trade.
Board of Trade merely sees that existing scientific methods are carried out, 12,709.

Council of India.
System of Council of India not desirable for a State council of scientific advice, 12,726.

Reed, E. J., Esq.—cont.

Council of Scientific Advice.
Desirability of having a State scientific council, controlled by a minister for science, &c.; members should not give all their time; they should be paid; they should initiate inquiries, 12,706–12,728.

Government.
Aid of Government essential to promotion of science, 12,706–12,728.

India Office: See *Council of India.*

Minister for Science.
Minister for science desirable; he should have a council of advice subordinate to him, 12,706–12,728.

Original Research.
State aid wanted to promote original research in connection with ship-building, &c., 12,706–12,723.

Science.
Government aid to science essential; many branches are undeveloped for want of means, 12,706–12,728.

Ship-building.
Important scientific matters relating to ship-building require development, 12,706–12,723.

GALTON, Captain DOUGLAS, C.B., F.R.S. (Index of his Evidence.)

British Museum.
Unnecessary duplication of functions at British Museum, South Kensington, and Kew, 12,987, 13,005–13,025.

Council of Scientific Advice.
State council for science desirable; it should not be merely consultative; it should control all scientific institutions and grants; five or six members and a secretary would be required; members should have salaries and pensions, 12,961–13,031.

Education.
All education should be framed with respect to scientific training, 12,981, 12,982.

Government.
Government promotion of science; consultative council desirable, 12,961–13,031.

Grants for Science Purposes.
State grants for science purposes should be administered systematically by a scientific council, 12,984.

Herbaria.
Overlapping of functions in herbaria of Kew, British Museum, and South Kensington, 12,987, 13,005–13,025.

India Office.
A Government scientific council should have a status similar to that of the India Office council, 12,984.

Kew Gardens.
Kew Gardens, South Kensington Museum, and British Museum overlap each other; they should all be under one government, 12,987, 13,005–13,025.

Laboratories.
Difficulty in the way of establishing laboratories for research, 13,032.

Original Research.
Practical difficulties would arise in instituting laboratories for original research, 13,032.

Science.
Promotion of science by Government; State council desirable, 12,961–13,031.
Want of uniform control over State scientific institutions, 12,961–13,032.
Science for governmental and for educational purposes should be separately considered, 12,964.
Necessity of statesmen having a scientific education, 12,966.
Scientific training of the mind should be the object of education, 12,981, 12,982.

Scientific Institutions.
Waste of force among State scientific institutions; they should be subject to one council, 12,961–13,032.

South Kensington Museum.
Doubtful if separate herbaria are wanted at South Kensington, Kew, and British Museum, 12,987, 13,005–13,025.

Superannuation.
Members of a consultative scientific council should have retiring pensions, 12,993, 12,994.

DE LA RUE, WARREN, Esq., D.C.L., F.R.S. (Index of his Evidence.)

Accommodation for Science Purposes.
State laboratories desirable, to accommodate 100 workers in chemistry and 50 in physics, 13,054–13,065, 13,074–13,093, 13,102–13,118.

Astronomy.
Government should take up physical astronomy, particularly sun observations; an observatory, separate from, but affiliated to, Greenwich Observatory, desirable, 13,066–13,073, 13,121–13,124.
Government should deal with only one chief astronomer, 13,069.

Australia.
Observatories for physical astronomy desirable in Australia, 13,071.

Cape of Good Hope.
An observatory for physical astronomy should be instituted at the Cape of Good Hope, 13,071.

Chemistry.
State chemical laboratory essential; director should possess the highest talent, 13,054–13,065, 13,074–13,093, 13,102–13,118.
Important researches made in Royal College of Chemistry, 13,055, 13,074–13,093.
Observatories for astronomical physics would require chemical laboratories, 13,066–13,073, 13,121–13,124.

Council of Scientific Advice.
State scientific council essential; all branches of science should be represented; 10 or 12 members, elected for five years, with 800*l.* or 1,000*l.* salary, desirable; council should issue reports, 13,035–13,136.

Germany.
Science greatly patronized in Germany; grand laboratories there, and more original research than in England, 13,054, 13,094–13,101.

Government.
Government has not appreciated science; more efficient aid is essential, 13,034–13,136.

Government Grant Committee. See *Grants for Science Purposes.*

Grants for Science Purposes.
Government grant of Royal Society is well administered, but insignificant in amount, 13,135.

Greenwich Observatory.
Observatory for physical astronomy wanted; it should be affiliated to Greenwich Observatory, 13,066–13,073, 13,121–13,124.

Income and Expenditure.
Members of a science council should have 800*l.* to 1,000*l.* a year, 13,045.
Two national laboratories, for chemistry and physics, would cost 50,000*l.* for building, and 10,000*l.* for outfit, 13,061.

India.
One or two observatories for physical astronomy should be instituted in India, 13,071.

Laboratories.
Importance of instituting State laboratories for chemistry and physics; these should accommodate 150 workers, 13,054–13,065, 13,074–13,093, 13,102–13,118.
Establishment of national laboratories would not harm existing institutions, 13,063.
Chemical laboratories are essential in observatories for astronomical physics, 13,066–13,073, 13,121–13,124.
Important laboratories in Germany; all connected with teaching institutions, 13,054, 13,094–13,101.
Aid to existing laboratories desirable, but institution of a national laboratory preferable, 13,105.

London.
State laboratories should be in London, with branches in the provinces, 13,056, 13,107, 13,109.

Mechanism.
Facilities should be afforded for the study of mechanism, by exhibition of models, &c., 13,062.

Minister for Science.
Minister for science essential; he should be aided by assistant secretaries and a council, 13,035–13,053, 13,119, 13,120, 13,125–13,136.

Observatories.
Observatories, with laboratories, for study of astronomical physics, should be instituted in England India, &c., 13,066–13,073, 13,121–13,124.

De La Rue, Warren, Esq.—cont.

Original Research.
Importance of instituting national laboratories for pursuit of original research, 13,054–13,065, 13,074–13,093, 13,102–13,118.
Valuable researches made at the Royal College of Chemistry, 13,055, 13,074–13,093.
Original research more successfully pursued in Germany than in England, 13,054, 13,094–13,101.

Photography.
Importance of carrying on photographic observation of the sun, &c., 13,066–13,073.

Physics.
Government laboratory for physical investigations essential, 13,054–13,065.
Desirability of State promotion of the physics of astronomy, 13,066–13,073, 13,121–13,124.

Royal College of Chemistry.
Promotion of original research in the Royal College of Chemistry; important arts developed; its alliance with the School of Mines, 13,055, 13,074–13,093.

Royal School of Mines. See *Royal College of Chemistry.*

Royal Society. See *Grants for Science Purposes.*

Science.
Want of more efficient aid to science by Government, 13,035–13,136.
Importance of having a State scientific secretary, aided by assistant secretaries, and a council, 13,035–13,136.
Encouragement to science in Germany, 13,054, 13,094–13,101.
Scientific careers should be open to qualified men in England as they are in Germany, 13,101.

Universities.
Continental laboratories are mostly connected with universities, &c., 13,055, 13,094–13,101.

DERBY, The Right Hon. EDWARD H. S., EARL OF, F.R.S. (Index of his Evidence.)

British Museum.
British Museum is supported by the State in the general interest of scientific culture, 13,508.
Council of science not necessary for management of British Museum, 13,535–13,537.
If the constitution of the British Museum were remodelled, the number of trustees might be reduced, 13,542.
Appointments in British Museum are made, practically, upon the recommendation of the permanent officers, 13,544.

Colleges.
A college for science, if liberally assisted by the State, would provide itself with laboratories, &c., 13,524, 13,525.

Committees.
Great amount of voluntary work done by committees; objection to theory concerning the small value of unpaid service, 13,532.

Contributions for Science Purposes.
Science should be aided by the State in a way that would stimulate private liberality, 13,508, 13,511, 13,513.

Council of Scientific Advice.
Objections to a State council of science; it would destroy the responsibility of the executive officer, 13,514–13,523, 13,533–13,541, 13,550, 13,551
No analogy between a council of science and the Council of India, 13,522.
A council of science would cause jealousy; its best members would have to do inferior work; and its practical direction would fall on the least scientific authorities, 13,523, 13,550.

Endowments.
Before applying to Parliament for aid to science existing endowments should be properly utilized, 13,509, 13,511.

Geographical Society. See *Royal Geographical Society.*

Government.
Assistance to science is a proper function of the State, 13,508–13,513.
State aid to science should be given so as to stimulate, not check, private liberality, 13,508, 13,511, 13,513.
Existing endowments for science should be properly utilized before application is made to Government, 13,509.

Derby, Earl of—*Government—cont.*
No town or district should be encouraged to apply to Government for science grants, 13,510.
Government can obtain the best scientific advice without the aid of a council, 13,514–13,526, 13,532–13,541.
See *Parliament.*

Grants for Science Purposes.
State grants for science should be given in a manner to stimulate private liberality, 13,508, 13,511, 13,513.
Grants by Government to scientific societies, &c. should be given for general, not special, purposes, 13,524, 13,525, 13,546–13,549.
Approval of Government Grant managed by Royal Society; Parliament might not object to increase the vote, 13,527–13,532.
See *Contributions for Science Purposes.*

Income and Expenditure.
Funds which science might require from the State would be insignificant compared to the national resources, 13,508, 13,531.

India Office.
Council of India and proposed council of science are not analogous, 13,522, 13,539.

Laboratories.
Colleges for science, liberally aided by the State, would provide laboratories, 13,524–13,526.

Minister of Education.
Application of State aid to science falls within the province of a Minister of Education, 13,517.

Observatories.
An observatory is a proper object for Government assistance, 13,512.

Original Research.
Scientific research should be promoted by the State, 13,513.
Men specially eminent for scientific research should be aided by Government, 13,523.

Parliament.
The minister would know better than a science council what Parliament would be likely to grant, 13,528, 13,534.
Parliament might not object to increase the vote to Government Grant Committee, 13,530.
Parliament must be assured, before granting aid to science, that existing endowments are made the most of, 13,509.
See *Government.*

Royal Geographical Society.
Geographical discovery best promoted by placing a certain yearly sum in the hands of the Geographical Society; for the money now given the public has an equivalent, 13,540, 13,547.

Royal Society.
Royal Society is the best representative body for science the Government can refer to; objection to its becoming an official council of advice, 13,528, 13,551.
See *Grants for Science Purposes.*

Science.
Aid to science is a proper function of Government, 13,508–13,513.
Necessity for existing endowments for science being made proper use of, 13,509, 13,511.
State aid to science should be subject to a fixed general rule; it should stimulate private liberality, 13,510–13,513, 13,527.
Scientific research should be promoted by Government, 13,513, 13,523.
Application of national funds to science is the province of a minister of education, 13,517.
Council for science not needed, 13,514–13,523, 13,533–13,541, 13,550, 13,551.
Aid to scientific societies, &c. should be for general, not special, purposes, 13,524, 13,525, 13,546–13,549.

Scientific Publications.
State grants should not be given specially for scientific publications, 13,546–13,549.

Scientific Societies.
Grants to scientific societies, &c. should be given for general, not special purposes, 13,510, 13,511, 13,524, 13,525, 13,546–13,549.

SALISBURY, THE MOST HON. R. A., MARQUESS OF, F.R.S. (Index of his Evidence.)

Apparatus for Science Purposes.
Advantage of Government promoting the scientific instruction of instrument makers, 13,575.

Appointment of Scientific Officers.
State appointments of scientific men for purposes of research; these should be made by Prime Minister, who should fill up vacancies, 13,567–13,570, 13,591–13,593, 13,609–13,611, 13,617–13,619.
British Museum appointments have been singularly well made, 13,605.

British Museum.
Approval of management of British Museum by trustees; it might be connected with Education Department by making President and Vice-president trustees, 13,579–13,581, 13,605–13,607.
Appointments in British Museum have been singularly well made, 13,605.

Committee of Council on Education. See *Education Department.*

Council of Scientific Advice.
Objection to a State council of science; Government can get the best advice without it, 13,560–13,564, 13,582–13,584, 13,594–13,600.
Council of India and proposed council of science are not analogous, 13,565.
Decisions of a council of science liable to be reversed by House of Commons, 13,564.
Council of science, as proposed, would be consulted by Government as little as possible, 13,600.
Royal Society Committee preferable to proposed council of science, 13,601–13,604.

Education.
Advancement of science is a pressing want of our educational system, 13,559.

Education Department.
Present Council of Education preferable for science purposes to a special minister, 13,577, 13,578.
British Museum might be connected with Education Department by making the President and Vice-president trustees, 13,579–13,581.

Fellowships.
Present application of revenues of fellowships is universally considered to be unsatisfactory, 13,571–13,573, 13,585.

Government.
Advancement of science is a duty of the State, 13,553–13,557.
Need of increased Government aid to science, 13,558, 13,559.
Government can get the best scientific advice without the aid of a council, 13,560–13,564, 13,582–13,584, 13,594–13,600.
Government aid to science should be given openly, not by means of an office which would be a sinecure, 13,560.
Desire to economize national funds is the chief impediment to Government aid to science, 13,557, 13,571, 13,574.
Wrong impression in some Government departments that scientific advice should be had gratuitously, 13,574.
Government support is clearly wanted for observatories, 13,575.
Impetus to research would be given if Government promoted scientific instruction among instrument makers, 13,575.

Government Grant Committee. See *Grants for Science Purposes.*

Grants for Science Purposes.
State grants for science have been withheld only by the natural desire to save public money, 13,557, 13,571, 13,574.
Government grants might properly be awarded to first-rate investigators, 13,590.
Government Grant Committee the best channel for administering national funds devoted to science; its grants might be much increased, 13,601–13,604, 13,608.
Special aid might be granted by Government to Scottish Universities, 13,620, 13,621.

Income and Expenditure.
Men appointed by the State for scientific research should have 1,000*l.* to 1,500*l.* a year, and superannuation allowance, 13,567–13,570.
Chief impediment to State aid to science is the idea of financial economy, 13,557, 13,571, 13,574.

SALISBURY, MARQUESS OF—cont.

India Office.
No analogy between proposed council of science and Council of India, 13,565, 13,594, 13,595.

Laboratories.
Except in places of education, State-aided laboratories are probably not needed; there being so many laboratories for commerce, 13,575.
Doubtful if State laboratories could be provided in sufficient numbers to satisfy demands, 13,590.

Law.
Government could obtain advice on questions of science as it does on questions of law; no council necessary, 13,561, 13,582–13,584.

Lectures.
A State-appointed scientific investigator should publish results in occasional lectures, 13,567, 13,591–13,593.

Lord President.
Practical connexion between British Museum and Education Department might be made by appointing Lord President and Vice-President trustees, 13,581.

Minister of Education.
A Minister of Education, directly in contact with science, would not be preferable to the Council of Education, 13,577, 13,578.

Observatories.
Support of observatories a duty of Government; more observatories probably required, 13,575.

Original Research.
Rapid progress of research where commercial value attaches to its results, 13,553.
Research is impeded by want of a career for scientific men, 13,553.
Government should aid men engaged in research not pecuniarily profitable, 13,560, 13,566–13,570.
State-appointed investigators should publish results, either in books or lectures; they should have 1,000*l.* to 1,500*l.* a year, and pensions; they might give advice to Government, 13,567–13,570, 13,591–13,593, 13,609.
Importance to research in having highly educated makers of scientific instruments; State aid for this purpose desirable, 13,575.
A moderate amount of teaching might be profitably combined with original research, 13,588, 13,589.
Government should not appoint men for original research until their qualifications had been fully proved, 13,589.
Scientific investigators might be best aided through the Royal Society, with its grant increased, 13,590.
Appointments of scientific investigators should be made by Prime Minister, 13,609–13,611.

Oxford University.
Small amount of scientific teaching at Oxford University, as compared with other subjects, 13,586, 13,587.

Parliament.
House of Commons would always be liable to reverse decision of council of science, 13,564.
See *Government.*

Prime Minister.
Government scientific investigators should receive their appointments from the Prime Minister, 13,610.

Royal Society.
State aid to scientific workers might best take the form of an increased grant to Royal Society, 13,590, 13,608.
Committee of Royal Society preferable to proposed council for science, 13,601–13,604.

Science.
Science is hindered by the want of a career for scientific men, 13,553, 13,554.
To promote science is a legitimate object of the State, 13,555–13,557.
Aid to science a pressing want of our educational system, 13,558, 13,559.
State aid to science should be given openly, not under the form of an office, 13,560.
Some Government departments have a wrong impression that scientific advice should be given them for nothing, 13,574.
Objections to a Government scientific council, 13,560–13,604.
State scientific investigators; their appointments should be made by the Prime Minister, 13,567–13,570, 13,591–13,593, 13,609–13,611, 13,617–13,619.
Scientific education of instrument makers a proper object for Government assistance, 13,575.
Science is becoming every day more recognised in the older universities, 13,612.
See *Grants for Science Purposes, Original Research, &c.*

SALISBURY, MARQUESS OF—*cont.*

Scotland.
- Scottish universities might receive special aid from Government, 13,620, 13,621.

Scientific Instruments.
- Makers of scientific instruments should have their education promoted by the State, 13,575.

Superannuation.
- Provisions for retirement would be essential for State-appointed scientific investigators, 13,569.

Universities.
- Desirability of better application of university funds to teaching purposes, 13,571–13,573, 13,585–13,587.
- Increasing recognition of science in the older universities, 13,612.
- While physical science should be promoted in universities, existing arrangements should not be disturbed, 13,612–13,616.
- Special aid might reasonably be given to Scotch Universities, 13,620, 13,621.

NORTHCOTE, THE RIGHT HON. SIR STAFFORD H., BART., C.B., M.P. (Index of his Evidence.)

Council of Scientific Advice.
- Objection to a State council of science, 13,635–13,656.
- A State council for science would come into collision with Government in respect to money matters, &c., 13,637, 13,638.

Education.
- Government should aid scientific, along with general, education, 13,623–13,625.
- Present endowments for education should be more utilized for scientific instruction, 13,627.

Endowments.
- Before granting public money for science, existing endowments should be properly applied, 13,627.

Government.
- The State should promote scientific, with general, education; it should aid research, and have means of obtaining scientific assistance, 13,623–13,628.
- Government aid to science might best be given through a system like that at South Kensington, 13,625.
- State aid should be given to those scientific researches of national importance which could be prosecuted only by its means, 13,629–13,632.
- Difficulty of Government obtaining scientific advice; science council objectionable; heads of departments should be responsible; advice might be sought from Royal Society, &c., 13,633–13,656.
- Objection to Government applying to irresponsible scientific advisers; a more systematic mode desirable, 13,647.

NORTHCOTE, The Right Hon. Sir Stafford—*cont.*

Grants for Science Purposes.
- State grants might be made for scientific, along with general, education; but endowments should be first properly applied, 13,623–13,627.
- Government Grant Committee a good scientific adviser for Government; it might be allowed increased means if necessity were shown, 13,642, 13,651, 13,652.
  See *Royal Society.*

India Office.
- Frequent applications involving science made to India Office; advice often desirable, 13,643, 13,644.

Minister of Education.
- The Minister of Education should have the best scientific advice, but for educational purposes only, 13,656.

Original Research.
- Government should promote important scientific inquiry where the work could not otherwise be done, 13,623, 13,629–13,632.

Royal Geographical Society.
- For advice as to explorations, Government might apply to Geographical Society, 13,646.

Royal Society.
- Royal Society a proper adviser for Government to apply to in scientific matters; payment might be made to it, 13,635–13,650.
  See *Grants for Science Purposes.*

Science.
- Scientific researches of national importance, which could not otherwise be undertaken, should be aided by the State, 13,623, 13,629–13,632.
- Along with general education, scientific instruction should be promoted by Government, 13,623–13,656.
- University scientific teaching might be stimulated by Government when present endowments are properly applied, 13,624–13,627.
- South Kensington plan a good system for promotion of science by the State, 13,625.
- Scientific advice difficult to be obtained by Government; objection to irresponsible advisers; scientific bodies might be consulted, 13,633–13,656.
- State council of science objectionable, 13,635–13,656.
- Approval of Royal Society as a scientific adviser of Goverment, 13,651, 13,652, 13,635–13,650.

Science and Art Department.
- State aid to science might best be given through a machinery like that at South Kensington, 13,625.

Survey Expeditions.
- Royal Geographical Society might be the best adviser of Government as to explorations, 13,646.

Universities.
- Government might stimulate scientific teaching in universities, but not till existing endowments have been properly applied, 13,624–13,627.

ANALYSIS OF EVIDENCE

RESPECTING THE

STANDARDS' DEPARTMENT OF THE BOARD OF TRADE.

CHISHOLM, HENRY W., Esq. (Index of his Evidence.)

America.
Weights and measures of America are established on a scientific basis, 11,656.

Apparatus for Science Purposes.
Charts and models for teaching weights and measures are used in France and Germany, 11,656.
Testing, preservation, &c. of Standards' Department apparatus; official verification of hydrometers and saccharometers is wanted, 11,720–11,735, 11,752.

Arithmetic.
Imperfection of arithmetic books generally, 11,656.
See *Weights and Measures.*

Astronomer Royal.
Exertions made by Astronomer Royal for improvement of Standards' system, 11,656, 11,705.

Austria.
Metric system in Austria; appointment of Imperial Standards' Commission, 11,656.

Bavaria.
Establishment of metric system in Bavaria, 11,656.

Board of Trade.
Board of Trade, and its connexion with Standards' Department, 11,655–11,754.

Chemistry.
National chemical laboratory would be serviceable to Standards' Department, 11,749–11,751.

Civil Service Commission. See *Examinations.*

Coinage.
New standard trial plates, for determining fineness of gold and silver coins, are being prepared at the Mint, 11,656, 11,751, 11,753.

Conservatoire des Arts et Métiers. See *France.*

Council of Scientific Advice.
State scientific council desirable; Standards' Department would benefit by it, 11,656, 11,673–11,677, 11,746–11,748.

Examinations.
Civil Service Commission an appropriate examiner for officers connected with Standards' Department, 11,678–11,684, 11,707.

France.
Conservatoire des Arts et Métiers is the principal weights and measures' department of France; lectures given there on metric system, 11,656.
International Metric Commission at Paris; delegates sent from most civilized countries, 11,656, 11,736–11,746.
Metric system in France; department managed by a scientific council, professors, &c.; taught in schools by models, 11,656, 11,673.

Gas.
Scientific gas-measuring standards; law respecting them imperfectly carried out, 11,656, 11,705, 11,706, 11,716, 11,718.

Germany.
Charts for teaching weights and measures issued by North German Standards' Commission, 11,656.
Metric system in Germany; weights and measures placed under a Central Standards' Commission, 11,656, 11,673, 11,714.

Government.
Apathy of Government in relation to accurate standards of weights and measures, 11,656, 11,685.

International Metric Commission.
Metric Commission at Paris, its objects, &c., 11,736–11,745.

CHISHOLM, H. W., Esq.—cont.

Laboratories.
National laboratories for physics and chemistry would be serviceable to Standards' Department, 11,749–11,751.

Lectures.
National scientific lectures on the metric system are given in France, 11,656.

Metallurgy.
Preparation of new standard trial plates for gold and silver coins, 11,656, 11,751, 11,753.
M. St. Claire Deville's experiments on alloys, &c.; such experiments would be of advantage here, 11,749–11,751.

Metric System.
Necessity for teaching metric system in schools, &c., 11,656.
International Metric Commission at Paris, 11,736–11,745.
See *Weights and Measures.*

Mint. See *Royal Mint.*

Physics.
National physical laboratory would be serviceable to Standards' Department, 11,749–11,751.

Professors.
Professors of Conservatoire des Arts et Métiers, Paris, lecture on metric system, 11,656.

Pyx, Trial of the.
Trial of the Pyx, and construction of new trial plates, 11,656, 11,751, 11,753.

Royal Commission on Standards. See *Standards.*

Royal Mint.
Preparation at the Mint of new standard trial plates, 11,656, 11,751, 11,753.

Royal School of Mines.
Royal School of Mines the only suitable place for undertaking metallurgical experiments for Standards' Department, 11,751.

Royal Society.
New standard yard constructed by Royal Society in 1742, 11,656.

Schools.
Necessity of teaching a uniform system of weights and measures in schools, 11,656, 11,708–11,714.

Science.
Science in relation to national standards of weights, &c., 11,655–11,754.
See *Standards.*

Standards.
National standards of weights, &c.; their relation to science, 11,655–11,754.
Royal Commission on Standards; reports and recommendations, 11,656, 11,668.
Apathy of Government in regard to accurate standards, 11,656, 11,685.
Gas-measuring standards; necessity for their careful manipulation, 11,656, 11,705, 11,706, 11,716, 11,718.
Legal standards burned with Houses of Parliament, 11,668.
Four principal copies of national standards are lodged with Astronomer Royal, Royal Society, Master of the Mint, and one walled up in House of Commons, 11,669.
Scientific re-verification of standards, under high scientific supervision, desirable, 11,671.
Recommendations as to introduction of uniform system of weights and measures, 11,707–11,715.
See *Weights and Measures.*

Chisholm, H. W., Esq.—cont.
Standards' Department.
  Status and scientific duties of Standards' Department, 11,655–11,754.
  Warden of Standards has no special scientific authority to appeal to, 11,665, 11,666.
  Approval of system of appointments in Standards' Department, 11,678–11,684, 11,707.
  Scientific apparatus of Standards' Department, its verification, &c., 11,720–11,735, 11,752.

Chisholm, H. W., Esq.—cont.
Weights and Measures.
  Efforts to establish scientifically accurate standards of weights and measures, 11,656.
  Necessity of a uniform system of weights and measures being taught in schools, 11,656, 11,708–11,714.
  Charts and models for teaching metric system of weights and measures in Germany and France, 11,656.
    See *Standards.*

LONDON:
Printed by George E. Eyre and William Spottiswoode,
Printers to the Queen's most Excellent Majesty.
For Her Majesty's Stationery Office.